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EARTHQUAKE RISK AND ITS ABATEMENT IN CALIFORNIA

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LONG experience has made it certain that the occur-
rence of earthquakes in and near California, and the
attendant risk that there is from this cause, are matters
not well understood by a vast majority of people both
inside the state and beyond its borders. For the most
part non-residents overestimate and residents under-
estimate the risk here from earth shocks. In both re-
spects so general a want of understanding is disadvan-
tageous to the region. From every point of view the
situation calls for clarification.

Manifestly there is some risk—of death, injury and
loss of property—in every actively seismic region
where very small earthquakes are frequent, somewhat

larger ones numerous, with the occurrence of shocks
of small destructiveness every year or two on the aver-
age, and moderate, large and great earthquakes at
longer and longer intervals. California is such a
region.¹ How great is this risk, and how is it spread?
What can be done to abate it?

Although the following discussion necessarily deals
specifically with California and the immediately neigh-
boring region, the general conclusions reached apply
also to seismic regions elsewhere, including some other
districts in the United States.

¹ See "Destructive and Near-destructive Earthquakes in
California and Western Nevada," U. S. Coast and Geo-
detic Survey, Special Publication No. 191.

HISTORICAL RECORD

The historical record of earthquakes in California and adjoining territory does not begin until the spring of 1769. Since earthquakes in a seismic region are recurrent geologic phenomena, and so should properly be considered in terms of the geologic time-scale—a scale which can not be divided precisely or appreciated, in brief units of scores or even hundreds of years—the interval since 1769 is far too short to permit any but tentative conclusions to be drawn regarding the true degree of seismicity of the region and the corresponding risk from this. However, the record for this interval in the California region can be compared with those for the same interval, or similar ones, in other regions. On such a basis, possibly an insufficient one, the risk in California appears significantly less than in many other seismic lands such as Chile, Italy, Asia Minor and Japan. Moreover, on this same basis, the risk in and near California is less, and less prevalent—especially with regard to continually impending danger in all places—than appears to be the wide-spread apprehension of large numbers of non-residents, as evidenced by innumerable letters, inquiries, conversations, press comments, etc., emanating from all parts of the country over an interval of many years. Though earthquakes can not be predicted, and a significant shock may occur at any time at some place within the region, as a matter of fact such shocks are by no means frequent in any one district and no such general apprehension is warranted either by the recorded history of shocks or by the probability based on geological considerations. No one in California lives in continual dread or fear of earth shaking.

PUBLIC INCOGNIZANCE OF RISK

On the other hand, there is some degree of risk, and the geographic spread of this risk over the region is wider than local residents generally realize. Risk is present in many places where people give no heed to it. There are several reasons for this. The historical record of shocks, such as it is, has not been readily available to most residents, and perhaps not very interesting to them. The great shocks, three in number, have occurred in different districts and at considerable intervals—in 1857, 1872 and 1906. The other large destructive shocks, about ten in number, have been separated fairly widely both in time and in place of occurrence, and this is also true in general of the thirty or so large to moderate earthquakes of more local character. Even shocks of small destructive force, though numerous in the region as a whole, usually have not affected any given small districts more than once in an interval of several years; and often they have been so small that the damage done has been very narrowly limited and sometimes of little moment. In

numerous localities people have lived for many years without suffering any damage whatever from earthquakes. The non-destructive felt shocks (excluding aftershocks following strong earthquakes) are not often very numerous in a given place, and frequently they give rise only to a thrill, or hardly that. The exceedingly numerous unfelt shocks registered by seismographs are known to but few who are not students of earthquake occurrence. Memories of strong shaking fade with time, or at least general awareness of such action dies away. The influx of population in the last twenty to forty years has been very large, on the whole increasing rapidly with the years, so that a very considerable part of the people now resident in the California region, including the younger generation, has practically no knowledge of the earthquake record nor any adequate conception of the frequency or spread of shocks. These things, with others, account for the fact that residents in many localities do not realize their risk. For example, quite genuinely a very great part of the people affected by strong shaking in the Long Beach earthquake in March, 1933, were surprised at the occurrence of a destructive local shock centering so close to the thickly settled Los Angeles plain—though persons acquainted with the record well know of the earlier occurrence of even greater shocks in the same district. The public simply does not know or appreciate the wide spread of such risk as there is—a risk which usually can be made negligible by suitable precautions.

RELATION OF EARTHQUAKES TO FAULTS

In a large number of cases the central areas of the important shocks have been intimately associated with geologic faults, and in some with the fresh offset slipping of these faults right up to the surface. In many cases this is known without any doubt whatever, and in many more any doubt that there may be is so slight as to be negligible practically, while in many others this association with faults is indicated very strongly, though the information in the historical record, not assembled by scientific men, may be insufficient to demonstrate such a relationship conclusively. It is generally held that most earthquakes are caused by the sudden release of elastic strain when this becomes greater than the strength of the rock, or more commonly of the cohesion or adhesion and friction in a zone of faulting previously broken and displaced—with new or renewed slipping, vibration and the radiation of elastic waves from the place of rupture, the source or origin of the shaking. Our knowledge on this point is not strictly conclusive, but this is the best judgment of qualified men of science, and this view has been widely accepted by well-informed members of the public. There is, however, an imperfect general

understanding of it and its practical meaning. It appears to be thought by almost all laymen that danger from shaking is confined to the very close vicinity of the fault source. Thus it happens that there are many inquiries from more far-seeing individuals and corporations regarding the location and course of faults, in the desire to avoid their immediate neighborhood in the erection or rental of residences or other buildings or works of construction. Wise as this attitude is in many circumstances, it is not sufficiently understood that close proximity to an active fault—which will sometime give rise to a significant earthquake—is only one of the factors, and usually not the most important one, in the risk or danger from shock occurrence. Such risk is far more widely spread. Of course, when the fault slipping extends up to the very surface of the ground any structure which is built astride the crack or cracks along which displacement takes place is bound to be damaged or destroyed unless it is constructed so strongly that it can ride along on its foundations on one side of the crack, leaving behind its foundations on the other—even in such a case extensive repairs will almost always be required, and any occupants will be subjected to great hazard and a very terrifying experience. Usually, however, the fault slipping does not extend up to the surface. And often, perhaps usually, the rocking and shaking is not so violent at the very innermost part of the central area, the so-called epicenter or epicentral tract, as at some small distance away from it. Thorough discussion of this relationship would require much space. Brief discussion may not be clear to all readers.

EARTHQUAKE WAVE-MOTION

However, this relationship appears to be due in part to the angle of emergence of the shock waves—strictly vertical vibration being less destructive to works of construction, built to withstand vertical stresses, than inclined or horizontal vibration; but even more to the apparent fact, which has strong theoretical support, that the *surface waves* (which seem usually to be far more destructive than the *elastic body waves* which first come up to the surface from the deep source of the shock) are generated and developed more effectively at small distances from the epicenter than at the epicenter itself. The size, shape and geographic location of the areas where these surface waves may be most effectively developed will depend not only upon the depth of the origin but also upon the mechanism or way of slipping of the fault. About this latter relationship we do not know very much as yet.

Of these surface waves there are surely two, probably three and possibly more kinds. There are two *elastic surface waves*, which have larger amplitudes of vibration than the original body waves. One of these

vibrates parallel to the surface and at right angles to lines along the surface radiating from the epicenter. The other vibrates in elliptical paths in the vertical planes which radiate from the epicenter. Of these the second should be the more destructive.

Further, there may be quasi-elastic, quasi-gravity waves of still larger amplitude. There are countless reports of *visible surface waves* which, if real, must be very destructive, since the amplitudes are described as large (up to two or more feet in the vertical) and the wave-lengths as short (six to twenty feet, more or less), the ground surface presenting a waving appearance like the disturbed surface of a body of water. We know positively that some of these reports are mistaken. It seems probable that most, if not all, are due to unconscious oscillatory disturbances of balance, perhaps to unconscious movements of the eyes, or possibly to a purely optical effect, and that such reported waves did not actually occur in the ground. But it may be possible that they are sometimes real and if so they must be very destructive.

Further still, there is little or no doubt that true gravity waves are set up in loose, wet ground, sometimes with very large amplitudes and very destructive potentiality. Also in such bad ground sometimes permanent wave-like deformation of the surface is observed accompanied by marked destructive effects. These phenomena are observed out to some considerable distance from the fault or epicenter depending on the size and strength of the earthquake.

There is also the possibility of the additive or subtractive combination of all these wave motions, body and surface alike, especially in a shock of prolonged duration, increasing the violence at one place and decreasing it at another. The resultant effect, as a whole, may be very complex.

EFFECT OF FOUNDATION GROUND

From the point of view of risk, far more important than this complexity of wave-motion in itself, or distance from the source (within a small range), is the nature of the ground at the surface. The energy or power of the shock, of course, is carried outward from the source by the several wave-motions, but the *effect* produced at the surface is *very greatly* different on different kinds of ground. Over and over and over again it has been observed that destructive effects are less on hard rock than on soft, less on soft rock than on alluvium or sand, greatest on marshy or filled ground, or "made land," especially when the latter are highly charged with water. There are innumerable examples of this, and exceptions to it are very few and of uncertain nature. The effects in San Francisco in 1906 afforded striking and detailed demonstration of it. There was far greater contrast between the damage

caused on the rocky summit of Telegraph Hill and that on the wet "made land" near the Ferry Building—places distant about ten miles from the fault source and less than a mile from each other—than there was on rock or firm ground over a range of twenty miles or more eastward from the Cliff House (which stood some four miles east from the fault). All over the area of the city the damage was far more closely related to the kind of ground at the surface than it was to the distance from the origin of the shaking. It is true, of course, that when *large ranges of distance from the earthquake source* are considered, near localities are more severely affected than far ones; but very bad ground not too distant is a much worse foundation than very good ground quite close at hand. *These facts can not be emphasized too strongly.*

GEOGRAPHIC SPREAD OF RISK

It is for the reasons given above that such risk as exists is spread far more widely than is generally known or appreciated. Further, active faults are more numerous than is generally known, and many of them are not shown clearly at the surface. Some probably are yet unrecognized, for some have become known only within the last ten to twenty years. A given locality may be safely distant from one potential source, questionably near another and dangerously close to a third. Not all such sources are equally dangerous, but close proximity to the source of a small or moderate destructive shock may be more dangerous than moderate proximity to the source of a really great shock, foundation ground and building structures being the same in both cases. Close proximity of inhabited places to the origins of earthquakes like those which affected Santa Barbara in 1925 and Long Beach and numerous neighboring cities and towns in 1933, shocks of only moderately large total energy /which, nevertheless, were destructive over comparatively small areas and of fairly high strength or intensity locally, show this clearly. Had the Long Beach shock been one of large total energy a great disaster would have resulted.

The wide spread of what risk there is from earth shaking in the California region is not a matter of hypothesis—it is a fact proved by the historical record. Since the earliest shock recorded in 1769, more than two hundred destructive and near-destructive earthquakes have occurred in and near California, including the forty-odd great, large and moderate shocks previously referred to. (Such shocks as the Santa Barbara and Long Beach earthquakes belong in the group of about 30 moderately strong local shocks).

For many years after 1769 inhabited places in California were few, small and mostly separated by large distances. With the gold rush in 1849 people began to come in much larger numbers, but only within the last

two or three decades has the population influx been really large and the number of cities, towns and villages become numerous and closely spaced. This applies with special force to the southern part of the state. Even to this day a great part of the area of California and adjoining territory is practically uninhabited—desert, mountain, forest, range and scantily peopled ranch land. Notwithstanding all this the inhabited places where damage from shock has been reported, at one time or another from 1769 onward, are so numerous and so widely and generally spread throughout the state that hardly any settled district can be considered free from some risk. This remains true, even when the comparatively large areas violently or strongly shaken during the dozen or so greater shocks are disregarded. Moreover, such a historical record as we have, under the circumstances outlined above, shows us only the *absolute minimum* of the geographic spread of risk, for the time interval is very short, approximately 170 years, population for a long time was small and sparsely distributed, and the body of information is very, very incomplete. Many places now inhabited must have been shaken strongly in the earlier years before their settlement, as well as places still unsettled, by shocks of which we have no adequate record, or none at all. If a map could be prepared to show all places in which shaking strong enough to damage structures has occurred since 1769 (if structures had been present like those which have been damaged from time to time in the past) a very large part, perhaps almost all, of California and western Nevada would be included.

GEOGRAPHIC VARIATION IN RISK

Although such risk as there is is general and widespread it is not everywhere the same. Between the extremes of greatest risk and least the margin may be wide, and probably it is; but it is extremely difficult with present knowledge to appraise the degree of risk for this, that or the other locality or site. No one knows where or when destructive shocks will originate, nor how large or strong they will be. Consequently no one can say when a particular locality or site will be shaken, nor how strongly. We do know some faults, such as the San Andreas, along parts of which strong earthquakes must originate in the future, as in the past; but we do not know when, nor which part will be affected on any particular occasion, nor how strongly. Other faults are under suspicion. Still others probably exist which are quite unknown to us now.

The important thing which we do know is that "made land" and fills, especially when water-soaked, are certainly dangerous in some localities and probably everywhere; that loose water-charged natural ground is more dangerous than dry compact ground; that soft

rock is less dangerous, and hard rock least dangerous of all. A well-designed and well-built structure on a good rock foundation near the source of a strong earthquake is, in general, in much less danger than a poorly designed, poorly built structure on bad foundation ground considerably more distant from the source. Thus, although there is some risk almost everywhere in the region—on the basis of the historical record the average risk is not great, nor danger always impending at all places. Such as it is, the risk can be greatly reduced if the facts are recognized and suitable precautions taken. On the other hand, if the facts go unrecognized or are disregarded, sooner or later earthquakes will take their toll. For example, the San Francisco shock occurred in 1906; in earlier years, as a matter of history, the Los Angeles plain district had been shaken strongly on several occasions. This was forgotten or disregarded. A great majority of the buildings and structures damaged there by the Long Beach earthquake in 1933 had been built later than 1906. Had the lessons of 1906 been applied to this recent building in the cities and towns of the Los Angeles plain very little damage need have occurred, with little or no loss of life and comparatively few injuries.

ABATEMENT OF RISK

Earthquakes can not be prevented, precipitated nor controlled—nor predicted except in a broad general way. The population in California is certain to increase greatly, and more and more cities, towns and villages will come into existence, and most existing centers will grow. Even the rural districts will become much more occupied by people. It follows that the thing to do is to build well and suitably on good ground wherever possible and to take special and adequate precautions in all cases where it appears necessary to build on doubtful or actually bad ground. (There is some ground, like the narrow surface zone of the San Andreas fault, where no important buildings should be built at all). At the present time this applies to all parts of the whole region, even though in the far distant future it may gradually become certain that some districts are, practically speaking, really safe from destructive shaking.

Unfortunately, there is one aspect of the risk as it now exists that will require time for abatement—even if the public should now become thoroughly cognizant of danger from shocks and remain always alert. During the rapid growth of population in recent years, at an ever increasing pace, all sorts of buildings and other works of construction have been built in great number on all kinds of foundation ground. Some construction, good from the earthquake point of view, is on good ground, some on bad ground, some on ground of inter-

mediate quality. Similar statements hold for construction of intermediate, and of bad design and workmanship. Some of this construction can be greatly strengthened at low or moderate cost; some can not. Immediate removal and replacement of all risky construction is a physical and economic impossibility. In the course of time all of it will be removed and most of it replaced. If, beginning now, all replacement is of construction suitable to resist earthquake shaking—gradually the risk will diminish toward a minimum. While we can hardly expect the maximum rate of abatement of risk in this way to be realized, important improvement in this regard can certainly be achieved. It should be stated that a beginning has been made and some progress achieved in the improvement of building codes and legal requirements for the construction of schools and other public buildings, but what is really required is general public realization and demand for suitable design and construction under all circumstances.

For the future the only safe procedure is to design and build well on good ground and with especial precaution on doubtful ground. There is still much to learn as to the better and best ways to design and construct. Studies to this end must go forward steadily even though a good deal is known now.

VALUE OF INSURANCE

Some protection against property loss and personal injury—and provision for dependents and heirs in case of death—can be obtained from insurance, but at best this recognizes risk of destructive effects, and these can be prevented in large measure though not eliminated completely by taking into account the wide spread of the danger from shaking and everywhere building well with this in mind. Even from the point of view of insurance this is the best procedure by far, for insurance rates will in time become much lower on good ground and good construction. The best insurance is suitably good construction, and the added cost on new structures is only a small percentage of the total investment. For a long time to come, however, some recourse to insurance policies will be judged necessary or desirable in a great many cases. So long as bad constructional conditions, taking foundation ground into account, remain existent individuals and corporations can protect themselves in considerable measure by selection in the purchase or rental of property and by recourse to insurance. The ideal, however, is the general lessening of danger by good new construction and the strengthening or replacement of old weak structures at the quickest practicable rate. From every unselfish point of view the enlightenment of the public regarding the true spread of risk and how to combat it is emphatically desirable.

MISLEADING STATISTICS

Present statistics, resting on far too slight a basis, indicate the risk to life and limb in California to be small—ridiculously small, less than the risk from common trivial diseases. But this is not a true picture. It is due to the past occurrence of the small number of greater shocks at fortunate times of day. Had the Long Beach earthquake, or that at Santa Barbara, for example, to say nothing of the San Francisco shock, occurred at unfavorable hours the statistical story would be a very different one. Energetic shocks will not always continue to occur at most favorable times of day. Some time one will happen when people are in the streets, or in theaters, churches, schools, etc. Once again the answer is the same. If all buildings are well built the risk will be small. Even panic will be reduced. If bad or unsuitable construction is general disaster or catastrophe will result. The moral is—design and build well on good ground, and in case of doubt insure. There is no other way to security.

To conclude—necessarily the greater part of this article deals with the risk that there is, its geographic spread over the region, and what can be done to lessen it. It is very desirable to fix the attention of residents

upon the actual situation and to persuade them to courses of procedure which will ensure greater and greater safety. On the other hand, as stated in the beginning, the risk from earthquake occurrence in the California region, though more general and widespread than most residents realize, is nevertheless much smaller than most non-residents and some local people commonly think—far less than the risk in many other parts of the country from hurricanes, floods, tornadoes and other natural causes of disaster. In justice to California and neighboring territory emphasis must be placed upon these facts. It would be unfair to the region if efforts to secure in it safe building and construction procedure should be construed as a warning of danger of great magnitude constantly impending at all places. While no one can foretell the future of earthquake occurrence in any practical way, the historical record since its beginning in 1769 gives no warrant for such alarm or serious apprehension. All that is warranted is recognition that earthquakes will continue to occur in the future as they have occurred in the past and that safety from the shaking requires good judgment in the selection of sites and the adoption of suitable resistant methods of construction.

THE ROLE OF AEROBIC PHOSPHORYLATION IN THE PASTEUR EFFECT

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A DECREASE in rate of carbohydrate utilization upon admission of oxygen is characteristic of many tissues. The various mechanisms which have been proposed for this Pasteur effect have been adequately reviewed by Burk.¹ It is the purpose of this note to call attention to a possible mechanism which does not appear to have been specifically mentioned elsewhere.

This mechanism is, in short, the following: If both aerobic and anaerobic carbohydrate breakdown are necessarily phosphorylative processes, inorganic phosphate and a phosphate acceptor are essential reactants; in their absence neither glycolysis nor oxidation could proceed. The Pasteur effect could then be regarded as the cessation or reversal of glycolysis which takes place when concentrations of inorganic phosphate and phosphate acceptors become low because of the phosphorylative oxidations which occur in the presence of oxygen. The necessary conditions for the operation of this mechanism are:

(1) The glycolysis reactions must be readily reversible.

¹ D. Burk, *Cold Spring Harbor Symposia on Quantitative Biology*, 7: 420, 1939.

(2) Phosphorylation (esterification of inorganic phosphate) must be an essential step in both the glycolytic and the oxidative processes.

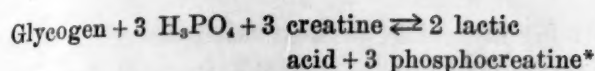
(3) The oxidative phosphorylation reactions must be capable of reducing the inorganic phosphate (and phosphate acceptor) concentration to a level lower than that attained at glycolytic equilibrium. That is, oxidative phosphorylation must be possible at inorganic phosphate concentrations too low to permit glycolytic phosphorylation.

(4) The number of molecules of phosphoric acid esterified when one molecule of carbohydrate is oxidized must be greater than the number esterified when one carbohydrate molecule is glycolized.

(5) The same reservoirs of phosphate ester, inorganic phosphate and phosphate acceptor must be available to both the glycolytic and the oxidative enzyme systems.

An adequate discussion of the likelihood that these conditions are actually fulfilled in isolated muscle can not be given here. Each point can be given only the briefest consideration.

(1) The glycolysis reaction may be summarized by the following equation:



(The participation of hydrogen ions is neglected for simplicity, although their inclusion would strengthen the argument.) The reactions summarized by the above equation, like any series of enzymatically catalyzed reactions, must necessarily be reversible. Whether appreciable reversal can take place under physiological conditions depends upon the position of the equilibrium point. That the equilibrium falls, in muscle glycolysis, well within the physiological range of reactant concentrations is elegantly illustrated by such data as those of Lundsgaard,² which show that after muscular work, glycolysis proceeds only to a definite equilibrium point. High concentrations of lactate occur only in the presence of high concentrations of creatine and inorganic phosphate (and low concentrations of phosphocreatine). High phosphocreatine concentrations and low phosphate concentrations permit the formation of only a limited amount of lactic acid. Experimental demonstrations of the ready reversibility of a number of component reactions of the glycolytic process have been given by Cori and Cori,³ Ohlmeyer,⁴ Meyerhof *et al.*,⁵ and others.

(2) Phosphorylation has long been recognized as a necessary component part of the glycolysis process. It has also been known that aerobic muscle recovery involves phosphorylation. Thus, Meyerhof and Nachmannsohn⁶ showed in 1930 that the oxygen uptake which resulted when oxygen was admitted to fatigued muscle brought about an amount of phosphocreatine resynthesis which was proportional to the amount of oxygen used. The mechanism of this phosphorylation is still unknown. Kalekar⁷ and Colowick, Welch, and Cori^{8,9} have shown phosphorylations to be in-

volved in biological oxidative processes. While it has not been shown that phosphorylation is an absolutely essential step in these oxidations, such an assumption at least does not appear too difficult.

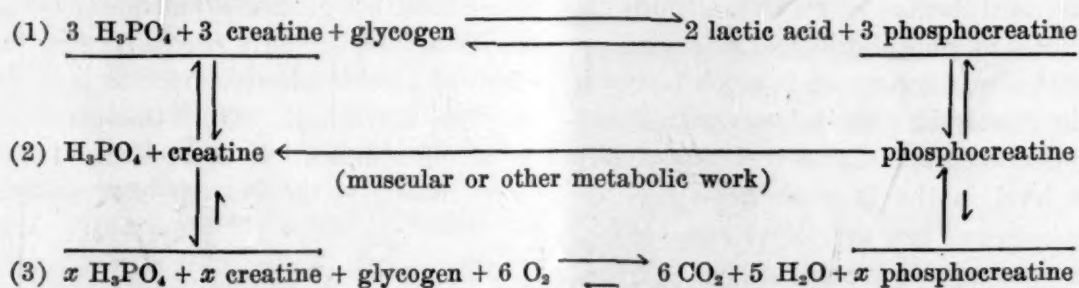
(3) The fact that aerobic phosphorylations are able⁶ to restore muscle phosphocreatine concentration to the resting level (with corresponding depletion of inorganic phosphate and creatine), while glycolytic phosphorylation stops far short of this achievement, seems sufficient evidence that oxidative phosphorylation is capable of operating at lower inorganic phosphate levels than is glycolytic phosphorylation.

(4) The number of molecules of inorganic phosphate esterified when one molecule of carbohydrate is completely oxidized has not as yet been accurately determined. Meyerhof and Nachmannsohn⁶ concluded that the number is at least 24 (4 to 5 molecules of phosphocreatine synthesized for each O₂ molecule used). There are, however, a number of reasons for believing that this figure may be too high. Colowick, Welch, and Cori⁹ recently obtained roughly two molecules of phosphate ester per molecule of O₂ used in pyruvate oxidation. Whatever the true figure may be, there seems to be little doubt that the number of aerobic phosphorylations per sugar molecule far exceeds the number of anaerobic phosphorylations (3 for glycogen, 2 for glucose).

(5) The availability of the same phosphate reservoir in muscle to both aerobic and anaerobic systems seems to be clearly demonstrated by the fact that either aerobic or anaerobic phosphocreatine resynthesis is possible.

On the basis of the above assumptions, the reactions taking place in isolated muscle could be expressed by the diagram below.

When a resting isolated muscle is stimulated, work



* In the present note the simplifying assumption will be made that phosphocreatine, the chief esterified phosphorus reservoir of muscle, is the only reservoir; the intermediation of such compounds as adenosinetriphosphate will be neglected. Since the various phosphate esters are in equilibrium with one another, this assumption is permissible.

² E. Lundsgaard, *Biochem. Z.*, 233: 322, 1931.

³ G. T. Cori and C. F. Cori, *Jour. Biol. Chem.*, 135: 733, 1940.

⁴ P. Ohlmeyer, *Biochem. Z.*, 283: 114, 1935.

⁵ O. Meyerhof, P. Ohlmeyer und W. Möhle, *Biochem. Z.*, 297: 113, 1938.

⁶ O. Meyerhof and D. Nachmannsohn, *Biochem. Z.*, 222: 1, 1930.

is done at the expense of energy of phosphorylation (reaction 2). Anaerobic restitution (reaction 1) immediately sets in, and proceeds rapidly toward the right until equilibrium is reached. At equilibrium, very considerable concentrations of inorganic phosphate and creatine still remain. If oxygen is now admitted, aerobic restitution (reaction 3) begins.

⁷ H. Kalekar, *Enzymologia*, 6: 209, 1939.

⁸ S. P. Colowick, M. S. Welch and C. F. Cori, *Jour. Biol. Chem.*, 133: 359, 1940.

⁹ S. P. Colowick, M. S. Welch and C. F. Cori, *Jour. Biol. Chem.*, 133: 641, 1940.

The resulting reduction in inorganic phosphate and creatine and increase in phosphocreatine displaces the equilibrium of reaction 1 toward the left. Glycogen resynthesis then begins, the inorganic phosphate thus produced being continuously reesterified by reaction 3. The mechanism of energy coupling is clear. A part of the energy of carbohydrate oxidation is converted to energy of phosphorylation by the aerobic phosphorylation mechanism. This energy of phosphorylation is then expended in resynthesizing glycogen from lactic acid.

In a steady state of rest or low work output, under aerobic conditions, glycolysis would be regulated by the fact that the aerobic phosphorylations can proceed at a lower concentration of inorganic phosphate than is compatible with an appreciable glycolysis rate. Furthermore, the rate of carbohydrate oxidation will be limited by the available concentration of inorganic phosphate. It would thus necessarily follow that oxidation is slow in the resting state because of the lack of the inorganic phosphate which is essential to the phosphorylative oxidation process. Only the liberation of inorganic phosphate concomitant with metabolic work would permit acceleration of carbohydrate oxidation. When the rate of inorganic phosphate liberation exceeds the rate of oxidative phosphorylation, the resulting accumulation of phosphate will accelerate glycolysis.

In view of the foregoing, the mechanism of the Pasteur effect in muscle and other tissues is readily outlined. Since oxidative phosphorylation is more energetic (*i.e.*, capable of attaining a higher phosphocreatine-creatine ratio) than glycolytic phosphorylation, the admission of oxygen to muscle rapidly reduces the level of inorganic phosphate and raises the phosphocreatine-creatine ratio until a point is reached where glycolysis must begin to reverse. Since the number of molecules of phosphoric acid esterified per molecule of carbohydrate consumed is much larger in oxidation than in glycolysis, a much lower rate of carbohydrate disappearance suffices to maintain a high phosphorylation level in the face of the energy de-

mands for muscular work or other energy-consuming reactions. One measure of the Pasteur effect is the number of carbohydrate molecules protected from glycolysis per carbohydrate molecule oxidized. This quotient should be equal to the ratio of the number of molecules of phosphoric acid esterified when a carbohydrate molecule is oxidized to the number esterified when a carbohydrate molecule is glycolized.

When yeast grows anaerobically its sole source of energy is, as far as present knowledge goes, the two molecules of phosphate ester which are produced when one molecule of glucose is converted into ethyl alcohol and carbon dioxide. In other words, the yeast cell seems able to utilize energy of phosphorylation for every energy requirement of its metabolism. It is only reasonable to suppose that aerobically, the energy of phosphorylation used by the cell is supplied by the phosphorylations accompanying aerobic oxidation. If the respiratory mechanism of yeast is similar to that of animal tissue, it may be assumed that the number of aerobic phosphorylations is sufficiently large to account for the decreased fermentation observed¹⁰ for yeast under aerobic conditions.

The Pasteur effect in yeast, as in muscle, would thus be interpreted as following from the fact that, aerobically, a relatively low rate of sugar utilization suffices to reesterify phosphate as rapidly as it is liberated by energy-consuming metabolic reactions.

Since the foregoing was submitted, the paper of Colowick *et al.* (*Jour. Biol. Chem.*, 137, 343, 1941) has appeared, in which it is concluded that at least 10 atoms of phosphate are esterified per glucose molecule oxidized. This is supporting evidence for point (4) above. Moreover, Cori (Biological Federation Annual Meeting, Chicago, April, 1941) has announced the experimental reversal of the conversion of glucose-1-phosphate into glucose-6-phosphate (point (1) above), and has independently reached the conclusion that energy of aerobic phosphorylation is utilized for carbohydrate resynthesis. Once this conclusion is reached, it becomes difficult to escape consideration of the interpretation of the Pasteur effect outlined above.

OBITUARY

GEORGE ELLETT COGHILL

GEORGE ELLETT COGHILL belonged to that small and select group of scientific workers who at the beginning of a fruitful career formulate a specific program of research with a clearly defined objective and thereafter devote themselves consistently and unfalteringly to intensive investigation of the chosen theme. In his case the problem has so wide implications and the results of the inquiry are of so great interest in fields as far apart as comparative embryology and human

motivation that it may safely be said that his work is one of the major American contributions to fundamental biology.

After completing the classical course at Brown University and a year of study in a conservative theological seminary, he found further effort in this direction unsatisfying. In perplexity and mental agitation he retired to the open spaces of the Southwest, where he spent five months of vagrant wandering in northern

¹⁰ O. Meyerhof, *Biochem. Z.*, 162: 43, 1925.

New Mexico. With horse and camp equipment he drifted as the mood directed, alone with his thoughts most of the time, but accompanied occasionally by his younger brother Will, who was then beginning his engineering education. This thinking in solitude culminated in the resolve to study the nervous system as a biological approach to a scientific psychology and a naturalistic philosophy.

This was in late summer, 1897, when a chance meeting with the president of the Territorial University at Albuquerque opened the way toward the accomplishment of his purpose. Three years of apprenticeship with President C. L. Herrick fixed his resolve and defined the objective. Returning to Brown University, he earned the Ph.D. degree in zoology, then taught zoology in three colleges, anatomy at the State University of Kansas, and later occupied a research position at the Wistar Institute of Anatomy and Biology.

He was born at Beaucaup, Illinois, on March 17, 1872. The academic record includes, A.B., Brown University, 1896, Ph.D., 1902; M.S., University of New Mexico, 1899, assistant professor of biology, 1899-1900; professor of biology, Pacific University, Oregon, 1902-1906; professor of biology, College of Arts, and of embryology and histology, College of Medicine, Willamette University, Oregon, 1906-1907; professor of zoology, Denison University, Ohio, 1907-1913; associate professor of anatomy, Kansas State University, 1913-1916, professor, 1916-1925, head of the department of anatomy and secretary of the School of Medicine, 1918-1925; professor of comparative anatomy, Wistar Institute, Philadelphia, 1925-1935. Broken in health, he retired in 1936 to Gainesville, Florida, where he built a dwelling and a small private laboratory and continued his research program as strength permitted until his death, July 23, 1941. Honorary Sc.D. degrees were received from Pittsburgh, Denison and Brown Universities. He was a member of the National Academy of Sciences, American Philosophical Society, American Association of Anatomists (president, 1933), American Society of Zoologists, American Neurological Association (associate) and other scientific societies. He was editorially connected with the *Journal of Comparative Neurology* from 1904 until his death and was managing editor from 1927 to 1933.

The task to which Dr. Coghill addressed himself can be stated very simply—the correlation of development of patterns of behavior with the progressive differentiation of the organs which execute the behavior. He selected for intensive study a primitive and generalized animal in which the essential features are reduced to simplest terms, the salamander, *Ambystoma*. In this choice he showed insight, for during the span of the forty years of his labor this has proved

to be the most serviceable type for a wide range of experimental researches. In this program he broke new ground in both aim and methods of work.

The first step was the determination upon statistically adequate numbers of specimens of the actual sequence of development of patterns of overt behavior characteristic of this species. A series of specimens, each of which was known by test to have reached a specific stage in this physiological scale, was then examined microscopically to detect the structural changes in internal organization correlated with the successive steps in the growth of the action system.

Most of the factual material published is included in the twelve parts of his "Correlated Anatomical and Physiological Studies of the Growth of the Nervous System of Amphibia."¹ These papers are models of close, accurately controlled observation and clear description, but the technical details are hard reading for any but experts in the field. As the mass of data began to reveal meaning to his mind he published from time to time brief summaries and interpretations. These papers are listed in the bibliography to be published.² The most important of them are the lectures on "Anatomy and the Problem of Behavior" delivered in London (Cambridge University Press, 1929) and the presidential address before the American Association of Anatomists on "The Neuro-embryologic Study of Behavior: Principles, Perspective and Aim."³

This was pioneer work, the first and until now the most complete account of the actual relationship between progressive differentiation of bodily structure and the operations of that structure as manifested in the maturation of patterns of overt behavior. The accuracy of the observations has been checked by numerous other observers and the conclusions drawn from them seem to be valid for the material studied. Caution must be observed in the extension of these principles to animals differently organized and with different developmental history. These questions will be clarified in due time, for many similar studies are now in process on the development of other animals from fishes to man.

The most important and far-reaching result of this series of researches is the impressive demonstration of the unity and integrity of the organism, the dominance of the "total pattern" over "partial patterns" at all stages of normal development, and illustrations of types of structural organization which perform both the integrative and the analytic functions. Dr. Coghill's original interest in the psychological and philosophical implications of his observations never waned, but unfortunately little of his thinking in these fields

¹ *Jour. Comp. Neur.*, 1914-1936.

² *Jour. Comp. Neur.*, Vol. 75, October, 1941.

³ *SCIENCE*, Vol. 78, 1933.

came to expression in print. Scattered comments in his lectures and theoretic papers show that his comprehension of the significance of his observations for psychology and philosophy was clear-cut and profound.

C. JUDSON HERRICK

THE UNIVERSITY OF CHICAGO

HARRY MILTON WEGEFORTH

HARRY MILTON WEGEFORTH, M.D., born in 1882, in Baltimore, Maryland, died in San Diego, California, on June 25, 1941, at the age of 59. He was a graduate of Maryland University in 1906. He practiced as physician and surgeon in San Diego from 1910 until 1935.

In 1916 he became interested in founding, organizing and developing the San Diego Zoo. He served as its president from its inception until his death, nearly 25 years. His first objective for the Zoo was to make it of value to the children of the community. To attain this objective, he pioneered many modern procedures; barless moated grottoes, animal family groups and lecture bus trips. To make the Zoo more realistic, he obtained plants from the countries from which the animals came and tried to make the entire background reflect the home environment.

He sponsored an animal hospital and research laboratory making available full utilization of animal exhibits both during exhibition and death for scientific

study. Research fellowships made possible the study of special problems in animal health.

By his leadership and example, he gained the confidence and support of the many friends that have made the San Diego Zoo a monument to his memory.

W. C. CRANDALL

LA JOLLA, CALIF.

RECENT DEATHS

DR. CHARLES BRANCH WILSON, biologist, from 1897 to 1932 head of the department of science of the Massachusetts State Teachers College at Westfield, died on August 18 in his eightieth year.

DR. ELLISON ADGER SMYTH, JR., until his retirement in 1925 professor of biology and from 1903 to 1906 dean of the faculty at Virginia Polytechnic Institute, died on August 19 at the age of seventy-seven years.

DR. JOHN MORPHY SNELL, since 1937 research chemist of the Eastman Kodak Company, died on August 8 in his thirty-fifth year.

A CORRESPONDENT writes: "Dr. Mataro Nagayo, formerly president of the Tokio Imperial University, Japan, director of the Japanese Foundation for Cancer Research, and the editor of *Gann*, the Japanese journal of cancer research, died on August 16 at the age of sixty-three years. In recognition of Dr. Nagayo's achievements, the Emperor of Japan conferred on him the title of Baron."

SCIENTIFIC EVENTS

FIELD WORK IN GEOLOGY IN CANADA

A PROGRAM of field work comprising the mapping and examination of many thousands of square miles of mineral areas throughout the Dominion of Canada is being undertaken this year by the Mines and Geology Branch, Department of Mines and Resources, Ottawa. Twenty-seven geological parties and nine topographical parties have been assigned to the work. A feature of the program is the investigation being made of possible commercial sources of tungsten, chromite and manganese, three of the strategic minerals, the production of which in Canada has been small.

Two of the geological parties are working in the Northwest Territories, one in Yukon, six in British Columbia, four in Alberta, one in Saskatchewan, one in Manitoba, two in Ontario, six in Quebec, one in New Brunswick and three in Nova Scotia. Two of the topographical parties have been assigned to British Columbia, two to Alberta, three to Quebec and two to Nova Scotia.

The program includes the following projects:

In British Columbia five of the geological parties are engaged in the mapping of areas in which deposits of mercury, chromite, gold, copper and other minerals occur, as an aid to prospecting and development. The areas are being mapped on a four-mile scale and have a total area of approximately 15,000 square miles. Another party is reexamining the geology of an important gold-producing area. A. F. Buckham is reexamining the Barkerville gold belt in the Cariboo district. Since 1934, when the area was last examined, its gold production has shown a threefold increase and developments at depth have disclosed structures, the relationship of which to the gold deposition is not clearly defined. The work in Alberta and Saskatchewan is part of the general effort to aid in the search for new oil fields. The Province of Alberta is the source of about 96 per cent. of Canada's annual output of crude petroleum.

In Quebec the geological and topographical exploration of the 40,000-square mile region east of James Bay, in charge of G. Shaw and J. Carroll, is one of the largest projects undertaken by the Mines and Geology Branch in recent years. The purpose is to produce an 8-mile-to-the-inch exploratory map; to outline areas favorable for prospecting, and to indicate the main travel routes. At

the request of the Metals Controller, investigation of the chromite deposits of southeastern Quebec is being continued. C. H. Stockwell is making the detailed investigations of the chromite-bearing rocks and is carrying out geophysical work for the purpose of locating deposits of the mineral. J. W. Ambrose is examining the igneous formations in which chromite occurs.

In New Brunswick F. J. Alcock is supervising the prospecting for deposits of manganese along the northwestern flank of Caledonia Mountain. The project is being undertaken at the request of the Provincial Government.

In the Yukon H. S. Bostock is continuing the geological mapping of the McQueston area near Keno on a four-mile scale. Rocks in the area contain tungsten, silver, lead and other minerals. He is also investigating occurrences of placer tungsten on Canadian Creek and is collecting information for use in a report on mining operations in Yukon.

In the Northwest Territories A. W. Jolliffe has been engaged in investigating the Gilmour Lake area about fifty miles due east of Yellowknife settlement as an immediate source of scheelite, an ore of tungsten.

THE AMERICAN COORDINATING COMMITTEE ON CORROSION

THE third annual meeting of the American Coordinating Committee on Corrosion was held on August 6 at Gibson Island, Md. The meeting was planned to coincide with the first Symposium on Corrosion, sponsored by Section C of the American Association for the Advancement of Science with the assistance of this coordinating committee. Dr. R. M. Burns, assistant chemical director of the Bell Telephone Laboratories, was chairman of the symposium. It was attended by approximately seventy invited specialists. The coordinating committee has offered its services to Section C to insure similar symposia in future years.

At the official committee meeting Dr. F. N. Speller, representing the American Chemical Society and the National Research Council, was reelected chairman for the year 1941-42; Dr. R. M. Burns, representing the Electrochemical Society, was named vice-chairman; and Dr. G. H. Young, of the Mellon Institute of Industrial Research, was named secretary-treasurer. Committee headquarters are at the Mellon Institute, Pittsburgh, Pa.

The committee was organized three years ago under the auspices of the American Society for Testing Materials to coordinate research activities in this field, and is patterned after similar organizations abroad. It has been functioning as an independent body for the past two years. As its first contribution, it undertook to survey existing investigations on corrosion in this country. Requests for information were submitted to some six hundred individuals and companies, through the executive offices of the member organizations of the committee. From the data thus accumulated the committee issued in 1940 a confiden-

tial directory of corrosion investigators and a classified list of subjects, which was sent to all those officially listed in the directory. This directory has now been expanded to include additional investigators and to broaden its subject classification. The revised directory was released on August 15.

The committee is at present composed of official delegates from the American Chemical Society, American Electroplaters Society, American Foundrymen's Association, American Gas Association, American Institute of Chemical Engineers, American Institute of Electrical Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Heating and Ventilating Engineers, American Society of Mechanical Engineers, American Society for Metals, American Society of Refrigerating Engineers, American Society for Testing Materials, American Water Works Association, American Welding Society, Battelle Memorial Institute, Copper and Brass Research Association, Electrochemical Society, Mellon Institute of Industrial Research, National Bureau of Standards, National District Heating Association, National Research Council, Society of Automotive Engineers and the Technical Association of Pulp and Paper Industry.

REPORT OF THE SUBCOMMITTEE ON EDUCATION FOR SERVICE OF THE AMERICAN MATHEMATICAL SOCIETY AND THE MATHEMATICAL ASSOCIATION OF AMERICA

A REPORT of activities and recommendations was recently presented to Professor Marston Morse, chairman of the War Preparedness Committee of the American Mathematical Society and the Mathematical Association of America by its Subcommittee on Education for Service. The active members of the subcommittee, who subscribe unanimously to the report are: R. S. Burington, H. B. Curry, E. C. Goldsworthy, W. L. Griffin, W. L. Hart, M. H. Ingraham and E. J. Moulton.

According to the report:

In arriving at an estimate of the mathematical background which is desirable for workers in government and industry, and for officers and enlisted men in the Army and Navy, we recognize the validity of the following pedagogical viewpoint: In order that an individual may be able to use effectively any particular body of technique, his school training should extend a reasonable distance beyond the level of difficulty at which he will apply the technique. Thus, if we wish to prepare a student so that, later, perhaps after some review, he can use elementary algebra, he should be exposed to advanced algebra, or to some other mathematical subject with elementary algebra as a prerequisite. This pedagogical viewpoint is at variance with emergency actions which would attempt to

give men the bare minima of mathematical techniques necessary for a formal approach to their applications. An emergency justifies any remedial action, but our efforts should be directed toward making it unnecessary to use hazy emergency shortcuts to mathematical procedures. With our wide-spread democratic system of secondary and collegiate education, our nation is justified in demanding that we should always have on hand a relative surplus of people with mathematical training through substantial secondary mathematics and also a surplus with elementary college training in the subject.

Further recommendations are taken up under the following headings: Statement of general viewpoints; Recommendations concerning mathematics for those in non-military activities; Evaluation of the mathematical needs of the Army and Navy; Conclusions drawn from results of the program of reviews of books of a mathematical nature used by the Army, Navy and Civil Aeronautics Authority; Recommendations concerning the field of secondary mathematics, and Curricular recommendations at the college level.

ELECTION TO BEIT MEMORIAL FELLOWSHIPS

A MEETING of the trustees of the Beit Memorial Fellowships for Medical Research was held on July 25. It is stated in the *London Times* that out of the 30 present fellows 13 had already been seconded at their own request for more direct service during the war, and that six others have undertaken some research work for Government Departments on problems arising out of the war.

The following elections were made, all with permission for each fellow to be seconded at any time for war duties:

Senior Fellowship (£700 a year).—T. R. R. Mann, M.D. (Lwow, Poland), Ph.D. (Cambridge).—To continue his work on intra-cellular metallo-protein compounds, especially of red blood cells. At the Molteno Institute of Biology, University of Cambridge.

Fourth Year Fellowships (£500 a year).—J. F. Danielli, B.Sc., Ph.D. (London).—To continue his work on the permeability of muscle fibers and of capillaries. At the Biochemical Laboratory, University of Cambridge.

Miss C. O. Hebb, M.A. (Dalhousie), Ph.D. (McGill University).—To continue her studies of physiological problems in relation to high altitudes. At the Department of Physiology, University of Edinburgh.

H. Lehmann, M.D. (Basle), Ph.D. (Cambridge).—To continue his work on the influence of shock and of the suprarenal glands on glycogen synthesis. At the Biochemical Laboratory, University of Cambridge.

Junior Fellowships (normal value £400 a year).—E. F. Gale, B.Sc. (London), Ph.D. (Cambridge).—1851 Exhibition Senior Student, Fellow of St. John's College, Cambridge.—To study bacterial amine production as a cause of non-specific infantile diarrhoea. At the Biochemical Laboratory, University of Cambridge.

W. Holmes, B.A. (Oxford), Christopher Welch Scholar in Biology, Senior Demy of Magdalen College.—To study the regeneration of nerve fibers after injury. At the Department of Zoology, University of Oxford.

Miss M. F. Lockett, M.D. (London), M.R.C.P., Owen-Roberts memorial scholar, London School of Medicine, research student in pharmacology, Cambridge.—To identify renal pressor substances responsible for experimental high blood pressure. At the Pharmacological Laboratory, University of Cambridge.

REPRESENTATION BY INSTITUTIONS AT THE MARINE BIOLOGICAL LABORATORY

The Collecting Net reports that there are 278 investigators present this summer at the Marine Biological Laboratory, Woods Hole, as compared with 293 at the same time last year. The following institutions are represented by three or more investigators:

Institution	1941	1940
Pennsylvania	30	34
New York	23	21
Columbia	18	22
Yale	13	8
Hopkins	12	8
Harvard	9	7
Ohio State	9	8
Chicago	8	13
Rockefeller Institute	8	9
Michigan	7	4
Princeton	7	5
Brown	6	5
Cornell	6	6
Pittsburgh	6	7
Cincinnati	5	4
Lilly Laboratories	5	4
Milton Academy	5	4
Vassar	5	2
Villanova	5	2
Washington	5	5
California	4	5
California Tech.	4	2
Iowa	4	4
Mt. Holyoke	4	2
Queens	4	4
Rochester	4	2
C. C. N. Y.	3	3
Illinois	3	2
Miami	3	2
Minnesota	3	2
Missouri	3	6
Oberlin	3	3
Syracuse	3	5
Temple	3	3
Toronto	3	5
Union	3	4
Williams	3	3

THE CHICAGO MEETING OF THE ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

THE forty-sixth annual meeting of the American Academy of Ophthalmology and Otolaryngology will be held at the Palmer House, Chicago, from October 19 to 23, under the presidency of Dr. Frank R. Spencer, of Boulder, Colo.

The program consists of one general scientific meeting on the morning of the first day, separate programs for the two specialties on alternate afternoons and instructional courses every morning beginning on Tuesday.

The feature of the general opening meeting will be a symposium on vertigo, with Dr. Francis H. Adler, Philadelphia, representing ophthalmology; Dr. William J. McNally, Montreal, otolaryngology, and Dr. Bernard Alpers, Philadelphia, neurology.

During the convention there will be various meetings of small groups, including the "Teachers' Section," secretaries of local eye, ear, nose and throat societies and alumni organizations. The meeting of the teachers' section will be concerned especially with the role of the academy in national defense during the present emergency. There will also be a scientific exhibit that will include such subjects as "Ocular Conditions in Children Due to Systemic Disease," "Conduction of Sound in the Ear," "Hemophilia and Other

Blood Dyscrasias as Manifest in the Eye, Ear, Nose and Throat," "Cancer of the Larynx" and "Significance of the Eyegrounds in the Problem of Hypertension."

Alternating with the scientific programs each afternoon will be an elaborate motion-picture program. Thus when the section of ophthalmology is meeting for formal presentation of papers, motion pictures on otolaryngology will be available for those interested in that field.

Dr. Perry Goldsmith, professor of otolaryngology in the University of Toronto Faculty of Medicine, Toronto, Ont., will be the guest of honor this year.

Officers of the academy in addition to Dr. Spencer are Drs. Ralph Irving Lloyd, Brooklyn, *president-elect*; Everett L. Goar, Houston, Texas; James M. Robb, Detroit, and Ralph O. Rychener, Memphis, Tenn., *vice-presidents*, and Secord H. Large, Cleveland, *comptroller*. Dr. William P. Wherry, Omaha, Nebr., is executive secretary-treasurer.

SCIENTIFIC NOTES AND NEWS

DR. WILLIAM DE B. MACNIDER, Kenan research professor of pharmacology at the University of North Carolina, who retired in July as dean of the Medical School, has been elected president of the Society for Experimental Biology and Medicine.

THE honorary degree of doctor of science has been conferred by the College of Wooster on Dr. Benjamin Harrison Willier, professor of zoology and chairman of the department of biology at the Johns Hopkins University.

DR. C.-E. A. WINSLOW, Lauder professor of public health at the School of Medicine of Yale University, has been appointed Rosenberg lecturer in the Public Social Services at the University of California for the fall semester of 1941. He will give two courses in the department of Social Welfare, one for undergraduates and one for graduate students, and will offer a lecture series open to the general public. In addition it is expected that he will travel throughout California to speak to various groups. The lectureship was established two years ago by the Rosenberg Foundation of San Francisco for the purpose of bringing to the university for one semester at a time distinguished authorities on the public social services.

THE second Sanford E. Thompson Award "for outstanding merit on concrete and concrete aggregates" presented at an annual meeting of the American Society for Testing Materials has been made to W. T. Thomson, assistant professor in the department of applied mechanics in the Kansas State College, in recognition of a paper entitled "A Method of Mea-

suring the Thermal Diffusivity and Conductivity of Stone and Concrete."

THE James R. Jewett and Vieno Johnson prizes, of \$100 and \$50, respectively, have been awarded by the Arnold Arboretum of Harvard University to Mrs. Wilfred O. White, of Boston and Vineyard Haven, Mass., and to Mrs. Ina Snow, of Truro, Mass., in appreciation of their interest in developing the utilization of the native beach plum, *Prunus maritima*. These prizes, made possible through the interest of Professor James R. Jewett, of Harvard University, are to be awarded annually to individuals who have made significant contributions to the improvement of the beach plum and other native fruit plants. This is the first award.

THE Melchett Medal of the British Institute of Fuels for 1941 has been awarded to Dr. Clarence A. Seyler, of Swansea, in recognition of his work on coal and its constitution. W. M. Selvey has been elected president of the institute to succeed Sir John Greenly.

FREDERICK OSBORN, research associate in anthropology at the American Museum of Natural History, has been nominated by President Roosevelt to be brigadier-general in command of the morale branch of the Army. He succeeds Brigadier-General James A. Ulio.

Nature reports that the sixty-seventh annual general meeting of the Physical Society, London, was held on July 25 with Professor Allan Ferguson in the chair. The reports of the council and of the treasurer were adopted and the following officers for

1941-42 elected. *President*: Dr. C. G. Darwin; *Honorary Treasurer*: Dr. C. C. Paterson; *Honorary Secretary (Business)*: Dr. W. Jevons; *Honorary Secretary (Papers)*: J. H. Awbery; *Honorary Librarian*: Dr. L. C. Martin; *New Members of Council*: Professor E. N. da C. Andrade and Dr. H. Shaw. Professor Ferguson will undertake the duty of acting-president until Dr. Darwin is able to take office. The council has to record a very successful year's work in difficult circumstances. Despite exceptionally heavy losses by death, the membership of the society is scarcely affected, standing at 1,070 members at the end of 1940, as compared with 1,084 members twelve months earlier.

PROMOTIONS to professorships at the University of Michigan include Dr. Dean B. McLaughlin and Dr. Will Carl Rufus, astronomy; Russell A. Dodge, engineering mechanics; John M. Nickelsen, mechanical engineering; Walter C. Sadler, civil engineering, and Dr. Henry Field, Jr., internal medicine.

DR. HARRY L. ALEXANDER, associate professor of clinical medicine at the School of Medicine of Washington University, St. Louis, has been made professor of clinical medicine and acting head of the department of internal medicine. He succeeds Dr. David P. Barr, who resigned to accept an appointment at the Cornell University Medical College, New York City.

DR. F. D. HEALD, professor in charge of the work in plant pathology at the State College of Washington since 1915, will retire with the title of emeritus on September 1 as head of the department of plant pathology of the college and head of the division of plant pathology in the Agricultural Experiment Station. He will continue his work in teaching and in research. Dr. Heald will be succeeded as head of the department and division by Dr. J. G. Harrar, associate professor of plant pathology and botany at the Virginia Polytechnic Institute.

DR. FRED F. MCKENZIE, of the University of Missouri, has been appointed head of the department of animal husbandry of the Utah State Agricultural College. Dr. McKenzie succeeds Dr. Ralph W. Phillips, who resigned to accept a position with the Federal Bureau of Animal Industry at Beltsville, Md., where he will have charge of animal genetics research for the bureau. Since the early part of May Dr. McKenzie has been in South America under the auspices of the Federal Department of State. His specific assignment has been to assist the Governments of Chili and Peru with their sheep-breeding problems at high altitudes, where considerable difficulty has been experienced in the fertility of the breeding stock. In Utah one of his chief responsibilities will be that of supervising a

program of research dealing with range livestock breeding and nutrition.

DR. EDGAR J. BOELL has been promoted from assistant to associate professor of biology at Yale University.

DR. EARL L. GREEN, post-doctoral fellow at the University of Chicago, has been appointed instructor in zoology at the Ohio State University, where he will teach genetics and biometry.

DR. O. C. STEWART has been appointed instructor in anthropology at the University of Minnesota.

DR. J. L. OTIS, professor of industrial psychology, and Dr. Oliver H. Ohmann, head of the department of psychology, will direct a Personnel Research Institute, which has been established in Cleveland College, the downtown department of Western Reserve University. The institute was made possible by an appropriation by the Thomas H. White Fund and by the aid of business firms and institutions.

DR. ENRIQUE WASHINGTON LITHGOW, of Ciudad Trujillo, head of the laboratory service at the Padre Billini Hospital of the Dominican Republic, will receive the fellowship founded in 1937 of the Dazian Foundation for Medical Research at Mount Sinai Hospital, New York City. He is on leave of absence and expects to return after spending a year in New York.

LORD HORDER has been appointed personal adviser to the British Minister of Food.

ACCORDING to the *London Times*, a certificate presented to the British Parliament by the Prime Minister enables Professor A. V. Hill, one of the members for the University of Cambridge who has become an associate member of the Ordnance Board appointed by the Minister of Supply, to retain his seat in the Commons.

FIELD MUSEUM OF NATURAL HISTORY is collaborating with the Institute of Andean Research, New York, in an archeological expedition to Ecuador. Donald Collier, recently appointed assistant curator of ethnology at the museum, has left Chicago and planned to sail from New York on August 29 to spend five months supervising archeological investigations for the institute. The project is sponsored by the coordinator of commercial and cultural relations of the American Republics.

DR. RAYMOND L. DITMARS, curator of reptiles and insects at the New York Zoological Park, sailed on August 19 for Trinidad to make a collection of vampire bats, stingless scorpions, giant cave crickets and cave roaches for a vampire bat cave to be opened at the park in October. The cave will be a reproduction

of a dimly lighted gallery in one of the Trinidad bat caves.

THE Biological Photographic Association, an international group of photographers in the natural sciences, will hold its eleventh annual meeting in the Hotel Buffalo, Buffalo, New York, on September 11, 12 and 13.

THE London *Times*, quoting from the *Soviet War News*, issued by the Soviet Embassy in London, states that the Royal Society sent on July 25 a message to the Academy of Sciences of U.S.S.R., Moscow, which reads: "Our united efforts will ensure that the future of science is not endangered by the destruction of those freedoms in which has thrived the work of the great scientists of both countries. In this struggle science has already made, and will continue to make, essential contributions to victory."

ACCORDING to *Nature*, the secretary of the Marine Biological Association reports that the Plymouth Laboratory, which a few months ago sustained heavy damage through enemy action, has now been restored to working order. Extensive emergency repairs have been carried out, accommodation for research workers is once more available and there are limited opportunities for work at sea in the motor boat of the association. It has, however, been necessary to transfer the greater part of the library to other quarters, and only recent volumes of current periodicals can now be consulted.

A UNITED PRESS dispatch from Berlin reports that there has been established in Germany an institute for vitamin testing and research "for the treatment of questions arising regarding the vitamin supply of the German people, and for the guidance of the government in measures to be taken." The institute will be directed by the Ministries of the Interior and Food.

THE New York City Board of Estimate has authorized an appropriation of \$375,000 as the initial cost of construction of the Nightingale Hospital for the treatment of cancer, which will be built at 163d Street and Fort Washington Avenue. The land is being given by the Columbia-Presbyterian Medical Center, which is adjacent, and the hospital will be conducted by the Department of Hospitals in conjunction with the College of Physicians and Surgeons of Columbia University, a part of the Medical Center.

The *News Edition* of the American Chemical Society reports that a three-story laboratory and office building has been completed at the Experimental Station of E. I. du Pont de Nemours and Company, Inc., Wilmington, Del. This replaces a smaller structure in which the laboratories have been housed since 1937, devoted to pest control research. The laboratory affords the most modern equipment for the study of insecticides and fungicides. A carbon-arc lamp, said

to be the closest approach to natural sunlight yet devised, has been installed in the adjacent greenhouse. The lamp gages the effects of sunlight on insecticides and fungicides on growing plants. An experimental garden plot that is used for preliminary testing of pesticides on plants adjoins the greenhouse. The new unit has been designed to permit the closest possible coordination of experimental and practical work, according to Wendell H. Tisdale, director. Extensive field trips are conducted under different regional conditions throughout the country. In addition to the usual problems of insect control, investigations at the laboratory include development of non-poisonous fungicides for use on stored agricultural products, such as fruits and vegetables; wood preservation for the control of stains, fungus decay and termites and for the treatment of cellulosic materials; preservation of harvested plant products, weed extermination and a study of plant hormones.

AN Institute of Gas Technology has been established at the Illinois Institute of Technology. The sum of \$100,000 per year for ten years will be provided for operating and maintenance expenses which will include the cost of instruction. Additional funds will be available for erection of buildings to house teaching and research activities. It is planned to open the institute at the beginning of the academic year in September. From five to ten fellowships will be granted during the first year. Seventeen gas companies are members of the organization group. Administration of the institute will be vested in a board of trustees made up of representatives of the gas industry and of the trustees of the institute.

THE zoological laboratory of Columbia University, under the direction of Professor Leslie C. Dunn, head of the department of zoology, is being enlarged and modernized. Reconstruction, it is expected, will be completed in time for the opening of the academic year. The floor space of the laboratory will be increased by 264 square feet. It will include a cold room for the storage of animal cadavers in which a constant temperature of 45 degrees will eliminate the need for any other form of preservative. The laboratory, which is on the sixth floor of Schermerhorn Hall, will provide permanent desk and cabinet space for forty-eight students instead of the twenty-four previously accommodated. The desks will be arranged in banks of six, each with one alternating and two direct current outlets. A sink with eighteen water faucets will be placed in each bank. A larger concentration of pre-medical students taking courses in embryology, histology and zoology has, in addition to the general deterioration of the original facilities, made necessary the reconstruction of the old laboratory.

DISCUSSION

THE INTERPRETATION OF EXPERIMENTAL
FOUR-FOLD TABLES

IN a note printed in *SCIENCE*, June 13, 1941, Dr. E. B. Wilson¹ discusses the discrepancy in the probabilities arrived at by two different methods of treating the four-fold table of experimental results, where groups of animals subjected to two contrasted treatments are recorded as having lived or died. He concludes by saying:

Hence there is neither logical nor arithmetic likelihood that the use of χ^2 should solve well our problem of determining whether the effects of treatment in experiment and control are statistically significant. It is still true, of course, that if numbers are sufficiently large, χ^2 will give the correct probabilities, but they have to be larger than is customary in such experiments.

Dr. Wilson is eminent among statisticians, both for his practical acumen and for his logical penetration. There is no one whose opinion I would sooner seek on the usefulness of any methods published in mathematical statistics. Yet in advocating the particular method he chooses for the interpretation of data of this important class he has, I believe, overlooked a difficulty which the approach based on, and giving the exact solution for, the classical view-point of χ^2 and the four-fold table, was expressly devised to obviate.²

Let us consider the simple example first discussed by Wilson. Of six treated mice five have died and one lived, while of six controlled mice one has died and five lived. Wilson considers the probability that the difference between the proportion dying in the two series shall be as great as, or greater than, that observed; that is, in the present instance, the aggregate probability of the six possible experimental results:

	Died	Lived	Total	Died	Lived	Total
(a)				(b)		
Treated	6	0	6	6	0	6
Control	2	4	6	1	5	6
Total	8	4	12	7	5	12
(c)				(d)		
Treated	6	0	6	5	1	6
Control	0	6	6	1	5	6
Total	6	6	12	6	6	12
(e)				(f)		
Treated	5	1	6	4	2	6
Control	0	6	6	0	6	6
Total	5	7	12	4	8	12

in contrast with all the remaining possible results, in which the difference between the numbers dying is not so great as four in favor of the treated series.

¹ E. B. Wilson, *SCIENCE*, 93: 557-560, 1941.

² R. A. Fisher, "Statistical Methods for Research Workers" (Section 21.02), Oliver and Boyd, Edinburgh. 1925-1941.

Assuming that the chance of death is one half in each series, the total probability of getting one or other of these six results is 79 out of 4,096, or 1.928 per cent. The basis of this assumption, which is not likely to be exactly true, is that the total number which died in both series together is just one half of the total under observation.

It is this circumstance which introduces a logical difficulty, for the probability assigned to the chosen group of possible results does not depend only on the results which constitute the group, but on the particular one of them which has been observed. Thus to the possible result (a) in which six of the treated mice died and two of the untreated, the probability $\frac{15}{4,096}$ or 0.3662 per cent. has been assigned in the calculation made above; but if this particular outcome had been observed a different probability, namely, $\frac{3840}{531441}$ or 0.7226 per cent. would have been ascribed to it, since the chance of death would be taken to be $\frac{3}{4}$. The probabilities arrived at by this method do not, in fact, correspond with any objective frequency distribution applicable to the whole aggregate of possible experimental results. Moreover, the probabilities assigned to each particular result, if it were observed, would not add up to unity.

The method which Wilson speaks of as the use of χ^2 , and which, though it is an exact arithmetical method, in which the χ^2 distribution is not employed, did arise from the study of the inadequacy of χ^2 when used with small numbers, proceeds on a different plane from the aggregate of all possible results of the experiment we select those, seven in number, which have the same marginal totals. These are:

	Died	Lived	Total	Died	Lived	Total
A				B		
Treated	6	0	6	5	1	6
Control	0	6	6	1	5	6
Total	6	6	12	6	6	12
C				D		
Treated	4	2	6	3	3	6
Control	2	4	6	3	3	6
Total	6	6	12	6	6	12
E				F		
Treated	2	4	6	1	5	6
Control	4	2	6	5	1	6
Total	6	6	12	6	6	12
G						
Treated	0	6	6			
Control	6	0	6			
Total	6	6	12			

Now it may be shown by simple algebra that *whatever is the probability of dying*, supposing this to be the same for the treated and the controlled series, the

relative frequencies with which these seven results will occur are the same, namely, out of 924 trials for which one or other of these seven observations is made, we may expect:

Result	A	B	C	D	E	F	G
Frequency	1	36	225	400	225	36	1

The possible results arrange themselves without ambiguity in order such that A is most favorable and G least favorable to the view that the treatment has increased the probability of death. The sum of the probabilities of the outcome observed and of the one more favorable possibility is $\frac{37}{924}$ or 4.0043 per cent.

We should, therefore, judge the result significant in favor of the view that treatment had increased the death rate, though not nearly so strongly significant as if we had relied on the first method of calculation.

Using the second method, it should be noted that the particular experimental result arrived at (B) determines without ambiguity both the series of results having the same marginal totals, with which its probability is to be compared, and its ordinal position in this series. Had any other observation within the same series been made, (B) would have been assigned the same probability, the sum of the probabilities of the members of each series being always unity.

The danger of using the double binomial is very clearly brought out by Wilson's comparison, for with small numbers the probability assigned is often no more than one third or one half of that given by my method. This is no doubt due to the method assuming some plausible value for the death rate among the controls as known to be true, an assumption which would be justified only if the number of animals used as control were increased indefinitely. If, for example, we knew this death rate to be one in six, the probability of observing so many as five dead among the treated series, having *ex hypothesi* the same death rate, would be only $\frac{31}{46656}$ or .0664 per cent. Our ignorance of the true death rate is, however, an essential part of the logical position, and is indeed the only reason why the control series is observed at all.

R. A. FISHER

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ELECTRICAL ACTIVITY OF ACETYLCHOLINE

ACETYLCHOLINE is produced by activity of the nervous system and has a stimulating action on ganglia and muscles, but the relation between acetylcholine and electrical phenomena in nerve is still obscure. Previous work¹ has shown that alkaloidal salts

¹ R. Beutner, *Jour. Am. Chem. Soc.*, 36: 2045, 1914; *Jour. Pharm. Exptl. Therap.*, 31: 305, 1927.

can produce electrical negativity when in contact with oil or lipoids. Moreover, it has been demonstrated² that acetylcholine modifies the electrical potential of skin in a negative direction. These findings led to the present experiments which show the production of a negative electrical potential by contact of an extremely dilute acetylcholine solution with various water-insoluble substances resembling lipoids.

In this model of electrical phenomena in nerve the oil layer (guaiacol, nitrobenzene, cresol, creosote or other substances) made contact on each side with 0.7 per cent. NaCl connected by salt bridges to beakers containing 0.7 per cent. NaCl into which dipped Ag-AgCl₂ electrodes leading to the E.M.F. terminals of a Leeds and Northrup thermionic amplifier (for high resistance circuits) serving as a null instrument for a potentiometer. In some experiments the surface of the oil to be treated made contact with 0.1 per cent. sodium benzoate which established a positive charge, thereby increasing the sensitivity of the layer to the negativity of acetylcholine. Mecholyl (acetyl-beta-methylcholine), acetylcholine chloride and acetylcholine bromide produced negative potentials which were proportional to the logarithm of the concentration. The highest potential obtained was 200 mv. with 0.03 per cent. mecholyl and nitrobenzene in saline. The lowest effective concentration obtained so far was one in one hundred million parts of acetylcholine chloride, which gave rise to 5 mv. (negative) on nitrobenzene in 0.1 per cent. sodium benzoate. Experiments now in progress indicate that the threshold is considerably lower than this concentration and may approach the value of 5×10^{-6} micrograms which Buchthal and Lindhard³ reported as the threshold concentration for stimulation of the end plate by acetylcholine introduced by a micromanipulator.

The electrical negativity following acetylcholine, compared with other alkaloids,¹ is remarkable for its size, its rapidity of appearance on application and disappearance after removal and for the extremely low concentrations required. These observations may support the hypothesis that perhaps acetylcholine produces a part of the negative electrical variation in nerve. Moreover, deNo⁴ has found that acetylcholine is liberated from nerve fibers as well as from synapses and Boell and Nachmansohn⁵ have recently reported that choline esterase is concentrated along the surface of the axon. Regardless of the theory of the nervous impulse adopted, we wish to draw attention to the pro-

² T. C. Barnes, *Amer. Jour. Physiol.*, 130: 557, 1940.

³ F. Buchthal and J. Lindhard, *Jour. Physiol.*, 95: 59P, 1939.

⁴ R. L. deNo, *SCIENCE*, 91: 501, 1940.

⁵ E. J. Boell and D. Nachmansohn, *SCIENCE*, 92: 513, 1940.

nounced electromotive activity of acetylcholine. No other substance in such diminutive concentrations is known to produce perceptible electromotive effects on second-class conductors.

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THE DETERMINATION OF THIAMIN BY THE YEAST FERMENTATION METHOD

A RECENT note in SCIENCE by H. H. Bunzell¹ described experiments on yeast fermentation in which only an 8 per cent. stimulation of fermentation rate was caused by thiamin, whereas a 106 per cent. stimulation was produced by an extract of wheat germ. Observations such as these naturally cast doubt upon the reliability of the yeast fermentation method for the determination of thiamin.^{2,3} In view of the widespread use of the latter method it was considered desirable to show how Bunzell's experiments differ from the published procedure.³

His description of the fermentation medium mentions a "nutrient" solution. This term does not occur in our paper,³ and thus there is no way of knowing exactly what his "nutrient" solution contained. However, on the basis of our experience with fermentation it is probable that his "nutrient" solution *did not contain ammonium ions* as required by the published procedure.³

Without ammonia in the medium thiamin causes a very slight stimulation and, conversely, without thiamin ammonia causes only a slight stimulation. The combination of the two in maximum amounts, however, causes a 100 per cent. increase in fermentation rate. This circumstance might explain Bunzell's results with the wheat germ extract since it has been shown⁴ that various amino acids, etc., have an effect equivalent to ammonium ions.

Bunzell's difficulties recall the experience of Smythe,⁵ who, observing a remarkable stimulation of fermentation due to an extract of bull testicle, finally isolated ammonium chloride as the active factor. Smythe made the additional mistake of obtaining his yeast from the small cakes sold in grocery stores. Such yeast is too rich in thiamin to show any stimulation of fermentation when thiamin is added to the medium.

¹ H. H. Bunzell, SCIENCE, 93: 238, 1941.

² A. S. Schultz, Lawrence Atkin and C. N. Frey, *Jour. Am. Chem. Soc.*, 59: 2457, 1937.

³ Lawrence Atkin, A. S. Schultz and C. N. Frey, *Jour. Biol. Chem.*, 129: 471, 1939.

⁴ A. S. Schultz, L. Atkin and C. N. Frey, *Cereal Chem.*, 16: 648, 1939.

⁵ C. V. Smythe, *Enzymologia*, 6: 9, 1939.

If the published procedure for the determination of thiamin³ is followed with ordinary attention to detail, a satisfactory determination of the thiamin content of wheat germ will be obtained.

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CONTROL OF RED SPIDER (TETRANYCHUS TELARIUS) BY PHTHALIC GLYCERYL ALKYD RESIN

THE common red spider (*Tetranychus telarius* L.), commonly found on greenhouse-grown plants and on many field crops, is extremely difficult to control. The ineffectiveness of many insecticides which have been recommended for control of red spiders may be ascribed to their lack of ovicidal action. Furthermore, chemicals which possess ovicidal properties are often injurious to cultivated plants, especially those grown in greenhouses.

In the course of an investigation, totally unrelated to the problem of red spider control, the writers observed that when a 2 per cent. phthalic glyceryl alkyd resin in water was applied to plants heavily infested with red spiders, the latter quickly disappeared. Microscopic examination of infested leaves showed large numbers of dead red spiders in all stages of development and masses of spiders' ova which had turned yellow and become shriveled after five days. Further examination of the ovicidal properties of phthalic glyceryl alkyd resin showed that it possesses a remarkable insecticidal efficiency. No injury was observed on plants tested experimentally under greenhouse and field conditions. Concentrations less than 2 per cent. (but not less than 1 per cent.) were effective on adults but not on ova; above 2 per cent. the margins of the leaves were burned.

The following plants were sprayed with beneficial results and without injury to the leaves: alfalfa (*Medicago sativa* L.), almond (*Prunus communis* Fritsch. and *P. nana* Stokes), apple (*Pyrus malus* L.), apricot (*Prunus armeniaca* L. and *P. mume* Sieb. & Zucc.), begonia (*Begonia octapetala* L'Her., *B. tuberhybrida* Voss., *B. semperflorens* Link and Otto, *B. haageana* Wats., and *B. rex* Putz.), *Coleus blumei* Benth., florists cyclamen (*Cyclamen indicum* L.), *Gardenia veitchii* Bailey, *Pelargonium* sp., grape (*Vitis vinifera* L.), *Hydrangea hortensis* Smith, India rubber plant (*Ficus elastica* Roxb.), ivy (*Hedera helix* L.), poinsettia (*Euphorbia pulcherrima* Willd.), plum (*Prunus americana* Marsh), rose (*Rosa* sp.), snapdragon (*Antirrhinum majus* L.), strawberry (*Fra-*

aria sp.), and tomato (*Lycopersicum esculentum* Mill. var. *vulgare* Bailey).

An unidentified species of a very minute, white mite occurring on ivy and China asters (*Callistephus chinensis* Nees) and a begonia mite (probably *Avrosia translucens* Nietner) were also successfully controlled by a single application of 2 per cent. solution of phthalic glyceryl alkyd resin.

Since these experiments for the control of red spiders were performed also in commercial greenhouses and in the field, it seems highly probable that this chemical may find a wide application. Additional advantages which it possesses include no disagreeable odor, lack of spray residue on the leaves, its high degree of spreading capacity and only one application is necessary for killing the adults and the ova.

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A BIRD LIST

IN SCIENCE, for July 18, you refer to a bird list,

made by Roger Peterson and myself (not my brother, Dr. Frederick H.) at the Fairehild Connecticut Gardens, on May 18, as a "bird census."

To my mind, it was in no sense a census, but simply a more or less superficial list of the species of birds noted during the course of a morning's walk through the area. The word "census" has been widely misused in this way in the past, and it would seem highly desirable to arrive at some general agreement as to what constitutes a "bird census."

If we adhere strictly to the dictionary definition of the word "census," a true bird census of a 127½-acre tract, swarming with migrants on the move, in addition to the resident species, would be almost impossible to take on a May morning. In view of the increasing need in ecological work for real censuses of the numbers and kinds of wild animals occurring on sample areas—it would seem wise to call any record, which does not represent a conscientious effort to record every single individual bird in the area at the time, a "bird count" or "bird list."

RICHARD H. POUGH

SCIENTIFIC BOOKS

ZOOLOGY

Text Book of Zoology. By the late T. JEFFERY PARKER, D.Sc., F.R.S., and the late WILLIAM A. HASWELL, M.A., D.Sc., F.R.S. Sixth Edition, in two volumes, Volume II revised by C. Forster-Cooper, M.A., Sc.D., F.R.S. xxiii + 758 pp.; 1-656 figs. 8vo. London: Macmillan and Co., Limited.

THIS famous text-book of zoology was originally a descriptive reference work of monumental character; it stemmed from the heroic period of T. H. Huxley, W. K. Parker and W. H. Flower but was not completed and published until 1898. Although both the volumes emphasized the factual side of development and morphology, the first volume, on the invertebrates, contained far more and better treatment of major phylogenetic problems than the second, which was for the most part merely an orderly record of bare facts with a minimum of inference. But these facts were so conveniently set forth that the rising demand has kept the work going through six editions.

In the first five editions some new details were added, but few radical changes were made and there was scant notice of the huge expansion of knowledge that had meanwhile taken place in the fields of vertebrate paleontology and general morphology. At last, however, the time came when it was realized that Parker and Haswell, Volume II, was in great need of modernization, and this formidable undertaking was then fortunately entrusted to C. Forster-Cooper, M.A.,

Sc.D., F.R.S., late director of the University Museum of Zoology at Cambridge and for some years director of the British Museum (Natural History).

The theme of the volume is the "Phylum Chordata," treated strictly from a taxonomic-anatomical viewpoint. In order to compress this enormous subject into practicable limits, the reviser has ignored many such significant techniques as the mathematical treatment of growth and form and the illimitable fields of genetics, physiology and the like; albeit that in many universities these are considered to be the central themes of modern zoology. But these subjects are already well represented by excellent contemporary text-books; whereas Parker and Haswell, Volume II, while still without a peer in its own territory, was getting to be so far behind the times that it might have been abandoned entirely in favor of a wholly new work. Thanks to the reviser and his collaborators, however, the old book has now been thoroughly rejuvenated or, more accurately, revised and enlarged. In its handsome new format we might even liken it to some stately building to which new extensions have been added but in such a way as to increase the usefulness of the parts and enhance the general effect of the whole.

The old text aimed to describe accurately the resemblances and differences between the innumerable products of vertebrate evolution; it but rarely referred to the changes in anatomical structure whereby one type has been transformed into another. The result

was a static picture of vast scope and intricacy, catalogued systematically and described with the aid of a countless multitude of technical terms. As clues to this labyrinth there were and are an excellent classification of the chordates in the table of contents and a most full and useful index, the latter now filling fifty-seven pages of three columns each. But though these and similar features still make the book invaluable as a reference work, they must at the same time have contributed to the sense of continued frustration, especially to those students who persisted in asking such questions as: "By what steps did this particular anatomical complex attain its present state?" or, "Through what successive grades and branches did this animal evolve?"

The best of the additions to the old text are those in which the reviser and his nearer colleagues and friends have themselves made major contributions: especially in the sections dealing with the paleozoic ostracoderms, placoderms and fishes, the earlier amphibians, the origin and adaptive branching of the main divisions of the reptiles, the rise of the mammal-like reptiles and the diverse evolution of the ungulate mammals. These were all very inadequately treated in earlier editions but are now concisely set forth with the aid of many new figures, diagrams and charts; all of which fairly shine forth from the ample pages. In the newer parts of the work the reviser aims to outline the history of each major group in so far as it can be reliably reconstructed from paleontologic evidence and to indicate its probable relationships with other larger groups. This is most admirably done for the perissodactyls and some other groups of ungulates among the mammals and in varying degrees for other vertebrates.

From a work that already gives so much it may seem unreasonable to ask for more; but we hope that in the next edition the reviser may preface the general chapter on chordate morphology with a critical review of the principal theories of the origin of the vertebrates. It may then be noted that theories involving the transposition of the primary invertebrate nerve cord from the functionally ventral to the functionally dorsal surface are based on similar but apparently convergent adaptations to forward locomotion in bilateral animals of widely different phyla, as between *Limulus* of the Arthropoda and *Cephalaspis* of the Vertebrata. And it seems further that the factual material might have gained added significance if it had been suggested that the typical piscine chordate is essentially a swift-moving predaceous fish, which is already far advanced beyond the stage of the earliest known chordates. These were the Ordovician, Silurian and Devonian ostracoderms, which were relatively slow-moving, partly bottom-feeding forms, whose head and thorax

were covered with a stiff dermal armor somewhat like dentine. Although these are well described and figured in the present work, it might have been noted that the studies of Stensiö, Heintz and Kiaer have led them to infer that the more or less continuous thoracic armor later broke down into the more flexible armor of such relatively swift-moving forms as the anaspids.

The present edition adopts the conservative view that the ostracoderms as a whole were an early side branch of the vertebrate stock, ancestral to the existing lampreys and hagfishes but definitely not ancestral to the true jaw-bearing or gnathostome branch of the vertebrates. While this may well be true of almost any given ostracoderm, it seems to the present reviewer far more likely that the general characters of the ostracoderms are truly primitive and that the jaw-bearing vertebrates in adopting predatory habits arose by greatly enlarging the branchial pouches, which are already present in the ostracoderms, and by emancipating the gill bars from the chondrocranium and modifying the anterior ones into jaws according to the stages recently suggested by Romer (1937). And in like manner, the placoderm stock, although giving rise to many side branches, seems in its basal characters to be structurally intermediate between the officially "jawless" ostracoderms and the typical gnathostomes.

In general the reviser seems to follow the current practice of assuming that the possession of any conspicuous specialization, such as the slightly movable joint across the skull roof of the Devonian rhipidistian fishes, debars its possessor from being ancestral to later forms which do not have this specialization. The reviewer, however, has seen many such cases in which it seems that earlier specializations become overshadowed by later ones and fade out of the hereditary pattern. However this may eventually prove to be, it seems safe to predict that in the publication of the sixth edition the second volume of Parker and Haswell enters upon a new and far wider career of popularity among advanced students and teachers of vertebrate zoology.

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SYMBOLIC LOGIC

Introduction to Logic (and to the methodology of deductive sciences). By ALFRED TARSKI. Enlarged and Revised Edition. New York: Oxford University Press. 1941. \$2.75.

THE last thirty years have witnessed a rapid and intense development of the symbolic study of logic and of its profound applications in mathematics, in

philosophy and in other disciplines depending on deductive thinking. Some of this development has been difficult for outsiders to follow, both because of the precision of the analysis used, and because of the complexity of the symbolic formulations necessary. There has long been a need for a clear-cut introduction to the new logic, which would state in an elementary but precise language the fundamental problems studied, and which would at the same time be free from an undue dependence upon traditional logic or upon special and controversial doctrines. The need has now been admirably met by this book, written by a distinguished Polish mathematician and logician who is widely known for his own fundamental contributions to logic.

Tarski's book begins with an elementary discussion of the notion of a variable and of the sentential calculus, which treats the properties of the basic logical connectives "and," "or," "not" and "implies"; subsequent chapters deal with the properties of identity, with the analysis of classes and with the calculus of relations. The chapter on axiomatic methods gives a careful elucidation of such fundamental concepts as the completeness and the consistency of a formalized deductive theory. It includes a discussion of some of Tarski's own recent results on the completeness of the ordinary system of Euclidean geometry. Roughly speaking, these results mean that every problem of *elementary* high-school geometry can be resolved by using the

ordinary procedures in a systematic manner. The second part of Tarski's book illustrates the previously developed concepts of logic and methodology by setting up two equivalent systems of axioms for the real numbers. These are the axioms which lie at the basis of calculus and higher mathematical analysis.

Throughout the book the symbolism is held to a minimum. The explanations are admirably clear and objective. The book itself is a considerably enlarged and improved version of a monograph previously published both in Polish and in German; the translation has been done by Olaf Helmer. This English edition contains much new material: many new and well-chosen exercises, some with hints and suggestions of further problems; some apt historical notes on the essential contributions of various logicians; a good critical bibliography; some eminently fair discussions of controversial issues, such as the distinction between the use and the mention of an expression and the divergent claims for "strict" and "material" implication. (On page 182 there is a disturbing misprint. In the second italicized statement, $z : x$ should be replaced by $z \cdot x$). All in all, this book is to be heartily recommended, both to the interested scientist who would like to discover what this logic business is all about and to the teacher searching for a dependable and accurate text for college courses in logic.

SAUNDERS MACLANE

HARVARD UNIVERSITY

REPORTS

THE ELLA SACHS PLOTZ FOUNDATION FOR THE ADVANCEMENT OF SCIENTIFIC INVESTIGATION

DURING the seventeenth year of the Ella Sachs Plotz Foundation for the Advancement of Scientific Investigation, eighty-one applications for grants were received by the trustees, fifty-one of which came from the United States, the other thirty coming from fifteen different countries in Europe, Asia, North and South America. The total number of grants made during this year was twenty-three, one of these being a continued annual grant.

In the seventeen years of its existence the foundation has made three hundred and ninety-four grants which have been distributed to investigators in Arabia, Argentina, Austria, Belgium, Brazil, Canada, Chile, China, Czecho-Slovakia, Denmark, Egypt, Estonia, Finland, France, Germany, Great Britain, Greece, Hungary, India, Iraq, Italy, Latvia, Lebanon, Netherlands, North Africa, Norway, Palestine, Poland, Portugal, Roumania, South Africa, Sweden, Switzerland, Syria, Venezuela, Yugoslavia and the United States.

The list of the investigators and the purposes of the research aided in the current year is as follows:

Professor William H. Adolph, Peiping, China, studies in calcium and oxalate metabolism.

Dr. Kenneth T. Bainbridge, Harvard University, biological research with radioactive isotopes.

Dr. Georg Barkan, Boston University School of Medicine, investigations in the field of hemoglobin determinations.

Dr. E. L. Borkon, Southern Illinois State Normal University, Carbondale, study of the compensatory hypertrophy occurring in a remaining kidney in hypothyroid, normal and hyperthyroid albino rats.

Dr. Siegbert Bornstein, Beth Israel Hospital, New York, continuation of investigations on the chemical constitution of the antigens within the Salmonella group.

Dr. Austin M. Brues, Collis P. Huntington Memorial Hospital, Boston, studies on regulation of growth in tissue cultures.

Professor D. R. Drury, University of Southern California School of Medicine, Los Angeles, continuation of work on the kidney and hypertension.

Professor Herbert Elias, New York Medical College, study of the influence of various ductless glands on the threshold of the kidney.

Dr. George Fahr, University of Minnesota Medical School, investigation of the effect of strophanthosid K upon the heart failure produced by chloroform, potassium ion and chloral hydrate; and investigation of the effect of narrowing the circumflex branch and the descending branch of the left coronary artery upon cardiac hypertrophy.

Dr. Allan L. Grafflin, Harvard Medical School, analysis of functions of living organs *in situ*, study of frozen sections, tissue spreads, blood smears, etc., with and without the addition of fluorescent compounds.

Dr. David E. Green, Harvard Medical School, work on the isolation of enzymes.

Dr. F. B. Gordon, University of Chicago, search for an etiological agent in rheumatic fever by means of inoculation of fetal animals and by culture.

Dr. Irvin M. Korr, New York University, research on the relation between tissue metabolism and physiological activity.

Dr. Fritz Lipman, Cornell University Medical College, New York, continuation of work on pyruvic acid oxidation.

Dr. Romano H. de Meio, Rosario, Argentina, South America, work on the action of sympathomimetic drugs on tissue respiration.

Dr. Ernst P. Pick, New York, investigation of brain tissue *in vitro*.

Dr. J. P. Quigley, Western Reserve University School of Medicine, Cleveland, study of the process of gastric evacuation.

Dr. George J. Scheff, New Haven, study of fluorescence.

Dr. A. K. Solomon, Harvard University, biological studies making use of artificial radioactive tracers.

Professor Barnett Sure, University of Arkansas College of Agriculture, Fayetteville, continuation of research on the vitamin C phase of the hyperthyroid problem.

Thorndike Memorial Laboratory, Boston City Hospital (Professor George R. Minot, Director), in recognition of Dr. Francis W. Peabody's services to the foundation.

Professor Charles W. Turner, University of Missouri College of Agriculture, Columbia, research on the endocrinology of lactation.

Dr. Earl Walker, University of Chicago, investigation of the eye movements elicitable from electrical stimulation on the striate, para- and peristriate cortex of the macaque monkey.

In their first statement regarding the purposes for

which the Fund would be used, the trustees expressed themselves as follows:

For the present, researches will be favored that are directed towards the solution of problems in medicine and surgery or in the branches of science bearing on medicine and surgery.

As a rule, preference will be given to researches on a single problem or on closely allied problems; it is hoped that investigators in this and in other countries may be found, whose work on similar or related problems may be assisted so that more rapid progress may be made possible.

Grants may be used for the purchase of apparatus and supplies that are needed for special investigations and for the payment of unusual expenses incident to such investigations, including technical assistance, but not for providing apparatus or materials which are ordinarily a part of laboratory equipment. Stipends for the support of investigators will be granted only under exceptional circumstances.

In the past few years the policy outlined in paragraph 2 has been neglected. During the present great need for funds, grants will be given in the sciences closely related to medicine without reference to special fields. The maximum size of grants will usually be less than \$500.

Members of the executive committee are: Drs. George B. Wislocki, *chairman*; A. Baird Hastings, Harry Plotz, Bernard Sachs, Paul J. Sachs, Soma Weiss, Joseph C. Aub, *Secretary*.

Applications for grants must state definitely the qualifications of the investigator, an accurate description of the research, the size of the grant requested and the specific use of the money to be expended. In their requests for aid, applicants should state whether or not they have approached other foundations for financial assistance. It is highly desirable to include letters of recommendation from the directors of the departments in which the work is to be done. Only applications complying with the above conditions will be considered.

Applications should be sent to Dr. Joseph C. Aub, Collis P. Huntington Memorial Hospital, 695 Huntington Avenue, Boston, Massachusetts, U. S. A.

SPECIAL ARTICLES

THE PREVENTION BY ALPHA-TOCOPHEROL OF "COD LIVER OIL MUSCULAR DYSTROPHY" IN THE RABBIT¹

THE injurious effect of cod liver oil in the herbivora has been demonstrated by the extensive investigations of Madsen, McCay and Maynard,² and Davis, May-

¹ Supported by grants from the Research Corporation of New York and the Carnegie Institution of Washington.

² L. L. Madsen, C. M. McCay and L. A. Maynard,

nard and McCay.³ Lesions of the skeletal muscles were observed in rabbits, guinea pigs, goats and sheep fed cod liver oil. The possible role of vitamin E was discussed, but no definite conclusion was reached.

Memoir 178 of the Cornell University Agricultural Experiment Station, 1935.

³ G. Davis, L. A. Maynard and C. M. McCay, Memoir 217 of the Cornell University Agricultural Experiment Station, 1938.

We have demonstrated⁴ the antidystrophic action of d,l-alpha-tocopherol (synthetic vitamin E) in rabbits fed a diet containing lard and cod liver oil, and have emphasized the fact that the absence of physical symptoms does not exclude extensive microscopic muscle lesions.⁵ Recently we have reported⁶ that acute muscular dystrophy could be produced in the absence of cod liver oil or other animal fats in rabbits reared on a synthetic diet. The oral administration of 3 mg of alpha-tocopherol 6 days a week to rabbits on this diet afforded complete protection against muscle lesions. The preventive action of the vitamin E was counteracted by the oral administration of 1 cc of cod liver oil soon after the vitamin E.

In more recent experiments employing the same synthetic diet, we attempted to prevent the action of cod liver oil by administering 6 mg of alpha-tocopherol⁷ orally on Mondays, Wednesdays and Fridays, and 2 cc of cod liver oil on Tuesdays, Thursdays and Saturdays. This procedure was employed by Shimotori, Emerson and Evans⁸ in preventing dystrophy in guinea pigs on a synthetic diet. The rabbits supplemented in this manner developed lesions of the skeletal muscles equaling in severity those produced when the same levels of alpha-tocopherol and cod liver oil were administered within a few minutes of each other, three times a week. In both cases the lesions were frequently not accompanied by overt symptoms.

However, when the dosage of alpha-tocopherol was increased to 40 mg every other day, the administration of 2 cc of cod liver oil on alternate days was without effect. No microscopic lesions were detected in the skeletal muscles. Thus it is clear that alpha-tocopherol when administered in sufficient amounts and under the conditions described protects the rabbit against muscular dystrophy produced by the administration of cod liver oil.

The following propositions have now been demonstrated on rabbits receiving the same basal ration: (1) severe dystrophy develops in rabbits on a vitamin E deficient diet in the absence of cod liver oil; (2) alpha-tocopherol prevents this dystrophy; (3) cod liver oil counteracts the antidystrophic action of alpha-tocopherol and produces muscle lesions, (4) increasing the alpha-tocopherol sufficiently prevents the dystrophic action of cod liver oil. It seems probable that this quantitative relationship also applies to

other species in which cod liver oil produces lesions of the skeletal muscles. A detailed report of these experiments will be published elsewhere.

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THE APPARENT EFFECT OF TYROTHRYCIN ON STREPTOCOCCUS HEMOLYTICUS IN THE RHINOPHARYNX OF CARRIERS

As yet no satisfactory method of eliminating pathogenic bacteria from the rhinopharynx of carriers has been devised. To this end a large number of chemical and physical agents have been unsuccessfully employed. Under the present conditions of shifting industrial populations and mobilization of troops, the problem again becomes urgent.

Dubos's recent isolation of a bactericidal substance from a soil bacillus ("tyrothrycin")^{1, 2, 3} suggested that this agent might be effective in clearing the rhinopharynx of certain bacteria such as hemolytic streptococcus, meningococcus, pneumococcus and the diphtheria bacillus.

From cultures of *B. brevis* kindly furnished by Dr. Dubos, "tyrothrycin" was prepared according to the procedure which he has described.³ The material was found to exert *in vitro* a lethal action on 18-hour broth cultures of hemolytic streptococcus, *staphylococcus aureus* and diphtheria bacillus (gravis strain) in a final dilution of 1:1,000,000, and on recently isolated strains of meningococcus (Type I) in a dilution of 1:100,000. The alcohol soluble fraction diluted 1:100 in normal saline containing 2.5 per cent. glycerine was introduced as a spray into the nose and throat of monkeys (*M. mulatta*) and of man. By means of copious spraying an attempt was made to cover as completely as possible the entire nasopharynx. This was often preceded by preliminary cleaning and shrinking of the mucous membranes. The active agent being insoluble in aqueous solution, vigorous shaking of the suspension was required immediately before use.

Separate nose and throat cultures from human beings were carried out for the demonstration of hemolytic streptococcus according to the method of Mueller.⁴

¹ R. J. Dubos, *Jour. Exp. Med.*, 70: 1, 1939.

² R. J. Dubos and R. Hotchkiss, *Jour. Biol. Chem.*, 136: 803, 1940.

³ R. J. Dubos and R. Hotchkiss, *Jour. Exp. Med.*, 73: 629, 1941.

⁴ J. H. Mueller and L. Whitman, *Jour. Bact.*, 21: 219, 1931.

⁴ C. G. Mackenzie and E. V. McCollum, *Jour. Nutrition*, 19: 345, 1940.

⁵ C. G. Mackenzie, M. D. Levine and E. V. McCollum, *Jour. Nutrition*, 20: 399, 1940.

⁶ C. G. Mackenzie, J. B. Mackenzie and E. V. McCollum, *Jour. Nutrition*, 21: 225, 1941.

⁷ We are indebted to Merck and Company, Inc., for the supply of alpha-tocopherol.

⁸ N. Shimotori, G. A. Emerson and H. M. Evans, *Jour. Nutrition*, 19: 547, 1940.

Preliminary trials in two monkeys which were found to carry in the nasopharynx and throat gram positive hemolytic streptococci and gram negative hemolytic bacilli (*Hemophilus hemolyticus*?) suggested that both these bacterial species disappeared within 2 hours following the administration of thyrothrycin. Cultures taken 5 days after a single treatment revealed no hemolytic colonies in the case of one monkey, whereas in that of the other they appeared only in the throat cultures. Following a second application at this time all cultures were negative within 3 hours. Repeated cultures remained negative for at least 4 days without further treatment. No local or general reactions to the material either in these animals or in a human volunteer were observed.

Accordingly, 5 human carriers of hemolytic streptococcus were treated. Two of them had been persistent nasal carriers for two months following scarlet fever, and 3 were convalescent in the third week of this disease. The results are presented in Table I. Only

given us by Dr. Edwin H. Place and the staff of the South Department of the Boston City Hospital.

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DEVELOPMENT OF HOMEOTHERMY IN BIRDS

ADULT birds are grouped with mammals as homeothermic or warm-blooded. The development of homeothermy occurs in the early life of the individual and corresponds to the increase in body temperature above that of the environment. This is accomplished through the appearance of special heat-regulating mechanisms presumably located in the base of the brain, in hypothalamus.¹

Observations show that homeothermy in birds occurs either early or late in the development, depending largely upon the developmental state of the young at

TABLE I
DATE OF CULTURE

Carrier		6/13	6/14	6/15	6/16	6/17	6/18	6/19	6/20	6/21	6/23
* L	{ N	+++	0	0	0	0	0	0	0	0	0
	{ T	0	S°	0	S 0	S 0	SS# 0	SS# 0	## 0	0	0
* McD	{ N	nd	nd	nd	++	+	+	0	0	0	0
	{ T	nd	S	nd	S nd	S ++	SS# 0	SS# ±	## 0	0	0
+ S	{ N	++++	++++	++++	++++	++++	±	++	++	0	0
	{ T	+++	++++	S +++	S +++	S +++	SS# ±	SS# 0	## 0	0	0
+ McC	{ N	++++	+++	±	++	0	0	0	+	0	0
	{ T	+	+	S +++	S ±	S 0	SS# 0	SS# 0	## 0	0	0
+ E	{ N	+++	++++	+++	++	+++	±	0	0	+	±
	{ T	0	++	S +++	S ++	S +++	SS# ±	SS# 0	## +	0	0

*—Chronic carrier. +—Convalescent scarlet fever patient. ±—1 col. on plate; +—2-5 col. on plate; ++—5-10 col.; +++—many col.; ++++—pure culture with plate hemolysed. nd—Culture not received. S—Spraying. SS—Two sprayings. #—Preliminary cleansing before spray. ##—Spraying stopped at this time. °—Spraying preceded subsequent cultures by 16-24 hours at all times.

in the case of carrier L was an immediate reduction in the number of streptococci obtained. In the others it was not until the fifth day that a striking diminution or disappearance of the organisms occurred, although 3 to 4 sprayings had been administered. This abrupt change on the fifth day we ascribe to the more intensive application of the thyrothrycin begun at that time which seemed warranted by the entire absence of reactions from the smaller orienting doses. These preliminary observations are insufficient to indicate the value of thyrothrycin in the elimination of hemolytic streptococcus from carriers. They are sufficiently encouraging, however, to justify further trial of the material not only against this type of carrier but against others harboring diphtheria bacilli, meningococci and pneumococci. We are now investigating these possibilities.

We gratefully acknowledge the clinical assistance

hatching. With altricial birds (pigeon, pelican), the young of which are naked and helpless for a while, the mechanism for the control of body temperature does not become effective until several days after hatching. Kendeigh and Baldwin^{2, 3} showed on the house wren that the body temperature of a nestling rises above the external temperature primarily during the fourth to ninth days after hatching. On the other hand, with precocious birds (chick, turkey, pheasant) the young of which are covered with down and soon leave the nest, the mechanism for the control of body temperature becomes effective much earlier, presumably before hatching.

As to the time of the development of homeothermy

¹ S. W. Ranson, *Rev. Publ. Assn. Nerv. Ment. Dis.*, 20: 342-399, 1940.

² S. C. Kendeigh and S. P. Baldwin, *Am. Naturalist*, 62: 249-278, 1928.

³ S. P. Baldwin and S. C. Kendeigh, *Cleveland Mus. Nat. History*, 3: 1-196, 1932.

the chick, Pembrey *et al.*^{4, 5} suggested, on the basis of response in gaseous metabolism to changing temperatures, that it occurs just before hatching. However, the observations of Eycleshymer⁶ and Penjonschewitsch and Rotanow⁷ indicate that the temperature of the developing egg begins to rise above the temperature of the incubator sometimes during the mid-period of embryonic development.

We have made a further and more detailed study of the temperature changes of the developing chick by the method of cultivation in an opened egg.^{8, 9} The plotted data in Fig. 1 in general agree with previous investigations, perhaps with the exception that at later stages of incubation the values are not so low as those of Eycleshymer,⁶ observed in water at 36.7° C., and not so high as those of Penjonschewitsch and Rotanow,⁷ observed in a still-air type incubator at 35° C. It is not unusual to observe such variation because both hypo- and hyperthermia in precocious birds can be produced experimentally¹⁰ even after hatching when there is a depression or elevation in the environmental temperature.

Our curve demonstrates that the developing chicken egg, although producing heat, at first behaves as a poikilothermic or "cold-blooded" animal. In a few days of incubation the temperature of the egg rises above that of the temperature of the incubator, and the embryo gradually becomes a homeothermic or "warm-blooded" animal. However, the true homeothermy presumably is not acquired by the chick until the fourth or fifth day after hatching¹¹

It is also interesting to note that the rise in temperature of the developing egg is not uniform but is somewhat periodic. The periods of decline in the temperature of the egg about the 9th or 10th day and

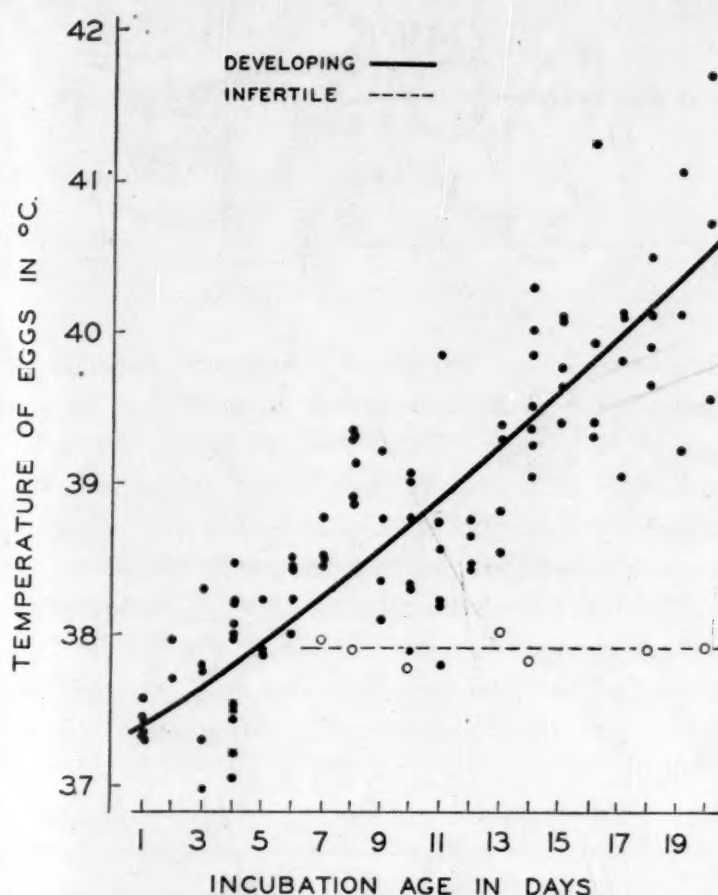


FIG. 1. Temperature changes of the developing eggs. Each dot represents the average value of several measurements on an individual egg. Circles indicate the temperature measurements of infertile eggs. All observations were made in the glass top incubator with slow air movement at the temperature on the level of thermocouple 37.75° C.

the 15th or 16th day coincide with the observed cyclical suppressions in the growth rate of the embryo.¹²

ALEXIS L. ROMANOFF

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

AN A. C. OPERATED ELECTRONIC INDUCTORIUM

ALL the various types of electronic inductoria with which the writer is familiar seem to have been designed to do some specific task and, consequently, little thought seems to have been given to the general applicability or low cost of these designs.¹ There has been

a need for an inductorium that would answer the everyday requirements of a physiology laboratory at the low cost and great convenience associated with most electronic devices.

Several inductoria have been constructed here which make use of the familiar saw-tooth wave generator circuit. They have been used for three years in the physiology and the pharmacology departments and have given trouble-free service with a considerable saving in the usual time of experimentation. The circuit

made by a thermocouple through the window of the egg at temperature of 37.75° C.

¹⁰ J. C. Scholes, Thesis, Cornell University, 1938.

¹¹ W. F. Lamoreux and F. B. Hutt, *Poultry Sci.*, 18: 70-75, 1939.

¹² A. L. Romanoff, *SCIENCE*, 70: 484, 1929.

¹ F. A. Fender, *SCIENCE*, 89: 491, 1939; O. A. Schmitt and O. F. Schmitt, *ibid.*, 76: 328, 1932; O. A. M. Wyss, *ibid.*, 84: 431, 1937.

⁴ M. S. Pembrey and M. H. Gordon, *Jour. Physiol.*, 16: vii, 1894.

⁵ M. S. Pembrey, M. H. Gordon and R. Warren, *Jour. Physiol.*, 17: 331-348, 1894-95.

⁶ A. C. Eycleshymer, *Biol. Bull.*, 12: 360-374, 1907.

⁷ E. E. Penjonschewitsch and A. N. Rotanow, *Arch. Geflügelkunde*, 8: 369-383, 1934.

⁸ A. L. Romanoff, *Anat. Rec.*, 48: 185-189, 1931.

⁹ This method permits to maintain a very uniform temperature in the egg free from interferences either of air movement or of changes in atmospheric pressure caused by the presence of egg-shell. The measurements were

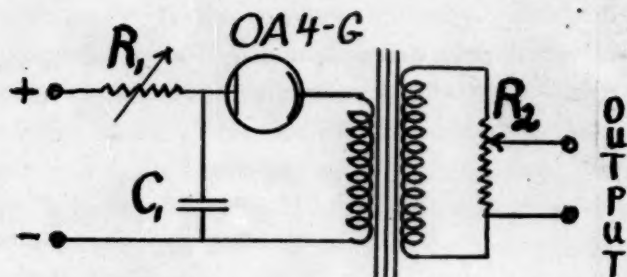


FIG. 1

diagrammed here provides frequency of stimulating impulses adjustable between the range of 2 to 60 impulses per second. Voltage and frequency are independently controlled by dials, single stimuli are obtained by operation of a push-button and a signal magnet is operated simultaneously with stimuli.

Fig. 1 is the schematic diagram of the stimulating voltage circuit. Variable resistor R_1 controls the frequency of the discharge of condenser C_1 through the primary of the transformer T_2 . Stimulating voltage

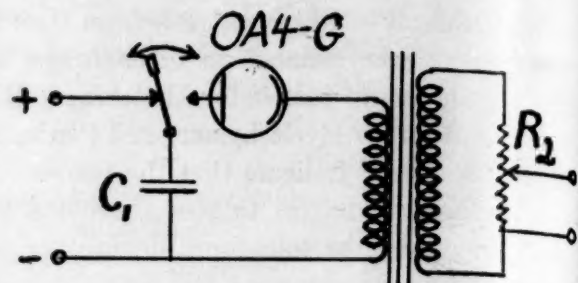


FIG. 2

- T_1, T_2 : 35-40 watt power transformer, 650 v, 6.3, and 5 volt secondaries
 Tubes : 5W4 rectifier; OA4-G gas-filled tube
 R_1 : 2 meg variable resistor
 SW_1 : SPDT switch
 R_2 : 20,000 ohm wire wound potentiometer
 SW_2 : SPST switch (mounted on R_2)
 R_3 : 30,000 ohm $\frac{1}{2}$ W. R_4 : 5,000 ohm 2W
 R_5, R_6 : 100,000 ohm 1 W
 C_1 : 0.1 mfd., 1,000 v condenser
 C_2 : 8 mfd., 450 working volts electrolytic condenser

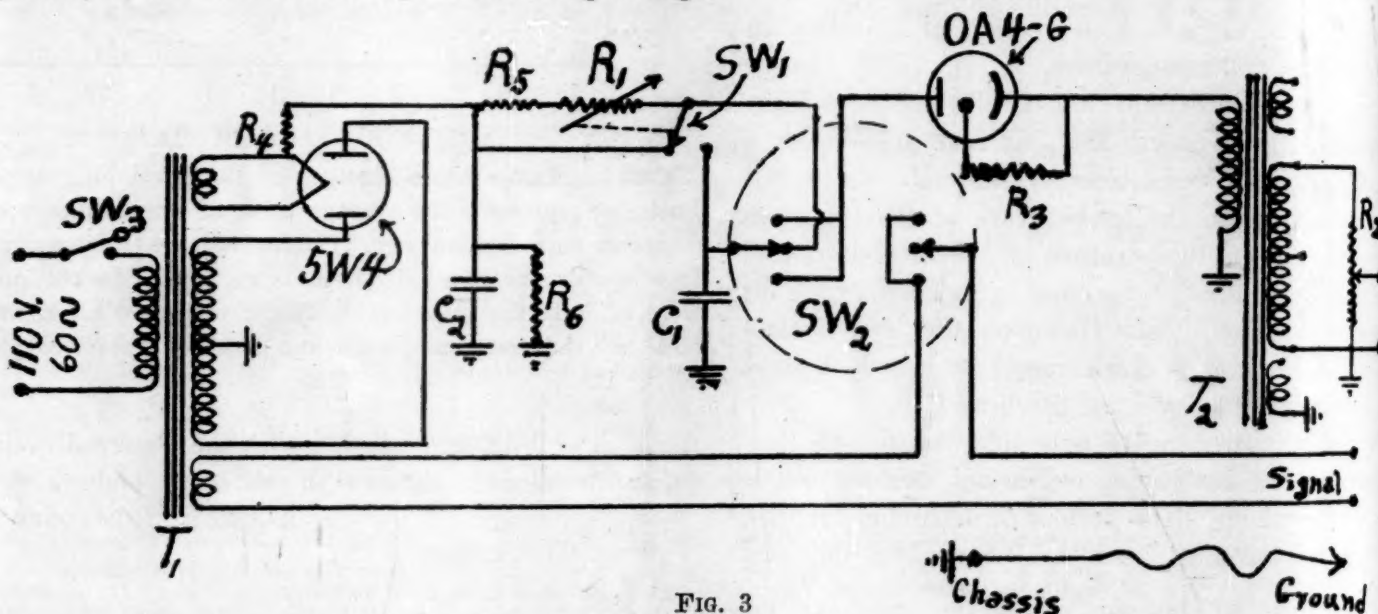


FIG. 3

is controlled by adjusting R_2 . It is apparent that there is no interaction of controls R_1 and R_2 . In Fig. 2 the schematic diagram for obtaining single stimuli is shown, and Fig. 3 is the actual circuit diagram of the entire apparatus.

In Fig. 3, switch SW_2 is a CRL type 1467, which functions in one position as a push-button, or key, and in the other position as a toggle switch. SW_1 , which mounts on the frequency control, R_1 , changes the circuit from that of Fig. 1 to that of Fig. 2. A ground wire for the chassis of the instrument is provided to prevent stray contractions caused by stray charges in the instrument.

All components mount in a commercial cabinet, 6" x 6" x 6". The controls and switches are on the top cover of the cabinet, and all other parts mount on a 5" x 5" sub-panel, suspended below the top cover.

Values of the parts, available at all large radio supply stores, follow:

A. B. CULLEN, JR.

UNIVERSITY OF MISSISSIPPI

BOOKS RECEIVED

- BRINKLEY, STUART R. *Principles of General Chemistry*. Third edition. Pp. x + 703. 179 figures. Macmillan. \$4.00.
 BUROS, OSCAR K., Editor. *The Second Yearbook of Research and Statistical Methodology*. Pp. xx + 388. Gryphon Press, Highland Park, N. J. \$5.00.
 CASE, VIRGINIA. *Your Personality—Introvert or Extrovert?* Pp. viii + 277. Macmillan. \$2.50.
 DOLE, MALCOLM. *The Glass Electrode*. Pp. xv + 332. Illustrated. Wiley. \$4.50.
 FORDER, HENRY G. *The Calculus of Extension*. Pp. xx + 490. Cambridge University Press, Macmillan. \$6.75.
 KANNING, EUGENE W. *Quantitative Analysis*. Second edition, revised. Pp. xx + 471. 58 figures. Prentice-Hall. \$3.70.
 NOYES, WILLIAM A., JR., and PHILIP A. LEIGHTON. *The Photochemistry of Gases*. Pp. 475. Illustrated. Reinhold. \$10.00.
 PALMER, RALPH S. *A Behavior Study of the Common Tern*. Pp. 119. 14 plates. Boston Society of Natural History.